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Bethesda. MD 20084 5000

The Electronic Delivery of Automated Technical Information for Logistics Support of Navy Weapon Systems: Potential, System Description, and Status

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This report presents a technical description and summarizes the technological status of a system for electronic delivery (presentation by means of a luminous screen) of fleet Technical Manuals (TMs) designed for logistic support of Navy Weapon Systems. Based largely on tests and analyses performed under the Navy Technical Information Presentation System (NTIPS) project, the report provides in detail the hardware and software requirements for a system which would fulfill this function, relates the acquisition of such a system to existing TM problems and procedures, and cites technological areas where further development is needed. It compares the effectiveness of electronically delivered TMs to conventional, page-oriented, paper TMs, and explores human-factors aspects of the man-machine interface involved. A survey of ongoing Navy efforts in the area of TM automation is included.

The report summarizes results of recent field tests in which TM electronic-delivery procedures were evaluated under operational conditions using active-duty fleet technicians as test subjects. An ongoing RDT&E program in support of TM electronic delivery is described;

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1.0 INTRODUCTION

1.1 BACKGROUND

Immense strides in the sophistication of weapon systems during the last two decades and the resulting demand for more complex Technical Manuals have outstripped the Navy's ability to improve conventional paper-based procedures sufficiently so that effective Technical Manuals can be supplied to maintenance technicians, system operators, and trainers for timely and effective use and support of these systems. In addition, non-standard acquisition and control techniques throughout the Navy have produced a proliferation of methods for acquiring, distributing, and using Technical Manuals.

Concurrently with the increase in weapon-system capability, many technological advances have also occurred in the field of information handling, primarily through the use of automation based on the advent of modern, highly capable, interactive computers. Thus, for the first time it is possible to create, control, and display Technical Manuals (TMs) to the end user in a fully automated and interactive fashion, with the virtual elimination of paper.

The need for amelioration of Technical Manual problems through the systematic application of computer-aided automation has been widely recognized throughout the Department of Defense and the Navy (as well as the Army and the Air Force). Summaries of deficiencies in the TM system, and directives that these deficiencies be reduced through the earliest possible

application of TM automation have been repeatedly promulgated.[1-6]

A SECNAV Instruction[2] notes, for example, that "Technical Manuals represent an enormous logistics investment for the Department of the Navy. The diversity of methods of procuring, maintaining, and updating Technical Manuals has resulted in significantly increased life cycle costs and inadequate provision of information required to train, operate, maintain, repair, and logistically support complex military systems and equipment."

An OPNAV Memorandum[4] has stated: "Despite various programs and purges over the years, proliferation of paper and publications in our warships continues unabated." In a review of the status of Navy Technical Manuals, the Navy Inspector General[5] points out that accurate technical documentation is "...the sine qua non of proper and safe operations as well as

1 DOD Instruction 4151.9 of 3 Jan., 1989.
  Subj: DOD Technical Manual Program Management

2 SECNAV Instruction 5219.2A of May 11, 1987. Subj: Technical Manual Program Management; Policies and Responsibilities for

3 DEPSECDEF MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS, of 24 Sept. 1985. Subj: Computer Aided Logistic Support

4 CNO 5000 Memo 03/D42211 of 24 December 1986; MEMORANDUM FOR THE DISTRIBUTION LIST. Subj: Removal of Paper and Publications from Ships

5 NAVINSGEN MEMORANDUM FOR THE UNDERSECRETARY OF THE NAVY via VCNO. Subj: Review of Navy Technical Manual Program. 9086 Ser 84/1533, June 27, 1984.

6 DEPSECDEF MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS AND DIRECTOR, DEFENSE LOGISTICS AGENCY, of 5 Aug 1988. Subj: Computer-Aided Acquisition and Logistic Support.

preventive and corrective maintenance - so readiness is an issue...". The IG adds that "the Fleet is outraged over poor TM quality."

In order to take advantage of the emergent technological breakthroughs in information-handling automation on a large scale, and to achieve the potential increases in acquisition- and logistics-support efficiency, the Department of Defense established[3] the DOD-wide Computer-aided Acquisition and Logistic Support (CALS) program. In 1988, the Deputy Secretary of Defense[6] re-emphasized the need for automation of logistics support, reviewed progress since his memorandum of 1985[3] was written, and provided the following directions:

a. For systems now in full-scale development or production, program managers shall review specific opportunities for cost savings or quality improvements that could result from changing weapon-system paper deliverables to digital delivery or access using the CALS standards.

b. For systems entering development after September 1988, acquisition plans, solicitations, and related documents should require specific schedule and cost proposals for: (1) integration of contractor technical information systems and processes, (2) authorized government access to contractor data bases, and (3) delivery of technical information in digital form.

c. DOD components shall program for automated systems to receive, store, distribute, and use digital weapon system technical information, including achieving the earliest possible date for digital input to DOD engineering data repositories.

1.2 PROBLEMS

During the past decade, a number of factors have combined to increase dissatisfaction throughout the DOD with existing paper forms of maintenance, operating, training, and logistic support Technical Information (TI) accompanying hardware systems. Major contributions to this dissatisfaction include the following:

a. A discrepancy between the reading capability characteristic of many categories of enlisted personnel and the readability level at which the Technical Manuals have been written.

b. The increasing complexity of many hardware systems, which has often resulted in a proliferation of the mass of paper required to support such systems.

c. Serious inflation of costs of conventional paper TI at a time when a high percentage of acquisition funds is being allocated to hardware procurement, with Technical Information (and other forms of logistic support) relegated to much lower priorities.

d. A drop-off in the rate of re-enlistment of many categories of technicians once they have achieved a small amount of system-support experience. This situation necessitates continued use of Technical Information as maintenance aids by less experienced technicians, with less guidance available from experienced personnel.

Moreover, numerous problems have long existed in the way the Services have specified, procured, maintained, and controlled their Technical Information. Complaints dealing with incomprehensibility, errors, configuration management, the difficulty of dealing logistically with large massive quantities of paper, and the inability to make timely corrections once errors are detected, have been rife for decades. General improvement in these areas has not been apparent.

In addition, paper-based TMs are growing increasingly bulky, continue to lack the organization and referencing that a technician requires to find quickly the data he needs, and continue to present complex maintenance procedures in terms which are poorly understood by technicians. The sheer weight and bulk of required paper TMs have become significant problems for shipboard use. Existing non-standard acquisition, update, and configuration-management procedures which attempt to print, transport, stock, and issue large quantities of paper manuals have resulted in decreased maintenance effectiveness, with an attendant deterioration of the level of readiness of fleet weapon systems.

1.3 ADVENT OF NEW TECHNOLOGY FOR INTERACTIVE ELECTRONIC DELIVERY

Coincidentally, the technological revolution which has taken place during the last ten years has been particularly significant in those information-processing areas which offer the possibility of eliminating paper from the entire Technical Information process. Many technological opportunities have arisen recently which offer great promise, both for short-term and for long-term solutions to specific TM problems, and for application on a Navy-wide basis to a longer-term, major

improvement of the entire TM situation. In at least ten technological areas, recent breakthroughs offer specific benefits to Navy TM acquisition, control, and display. These technological areas are as follows:

1.3.1 Establishment of Automated TM-Generation in Industry

An automated TM-generation capability now has been widely established throughout Industry, with wide adoption of computer-controlled work stations for creation and merge of text and graphics TM information. As a result, the Navy can realistically expect that specifications delineating its requirements for automated TMs can be readily met by weapon-systems prime contractors. Moreover, both in Industry and in the DOD, extensive standardization efforts are under way to achieve uniformity in automated TI.

1.3.2 Greater Information-Storage Density

Orders-of-magnitude improvement in information storage density have occurred, with essentially instant retrieval (random access) capability now available. Optical-disc storage technology now permits elimination of logistics problems arising from the sheer bulk and weight required by paper Manuals, and at the same time (when a TM is properly designed) offers greatly improved access to specific information required by a technician.

1.3.3 Development of Highly Capable Computers

Small, inexpensive, highly versatile computers have been developed, with sophisticated graphics capabilities (involving Scroll, Zoom, and Windowing), large internal memory, great speed, available in rugged, reliable packages. This revolution offers great improvement in essentially all steps of the TM process: generation, control, update, distribution, and information display.

1.3.4 Development of Laser Printers

Off-the-shelf availability of relatively low-cost laser printers has been achieved. TMs, or sections of TMs, can now be printed locally, quickly, and with high quality, using desktop printers, under the control of "driver tapes", which are individually constructed by automated TM-generation methods, or prepared by scanning existing TMs. Thus Print-On-Demand approaches at user activities have become a real possibility.

1.3.5 Improvement in Software for Information Scanning

Recent software advances have made possible the transformation of scanned images. For example, an existing TM may be scanned and converted into a form from which the material may be reformatted for greater effectiveness, corrected, updated, or overlaid with "intelligent" retrieval commands for greater accessibility.

1.3.6 Improved TM Display Systems

Significant advancements in TM electronic-display hardware and software have taken place. New techniques for presenting troubleshooting and corrective maintenance have been developed and field-tested, and have produced significant improvement in technician performance.   New presentation techniques (electroluminescent, illuminated liquid-crystal, and plasma screens) in small rugged packages are being developed by Industry, so that interactive TMs can be displayed electronically to technicians in work centers or at remote maintenance sites with portable devices.

1.3.7 Better DBMS Technology

Greatly improved Data Base Management System (DBMS) software has been developed. Over the last few years, it has

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become far simpler to design, control, and use the data bases of the great size required for the Navy's total quantity of TMs, which must be made available to a great number of users. Relational data base techniques, in particular, have made it much easier to modify the data bases to meet changing requirements.

1.3.8 Advances in Information Networking Technology

Broad improvements have been made in software and communications technology involved in Wide Area Networking (WAN) and Local Area Networking (LAN), for both land-based and shipboard information-distribution systems.

Automated TM distribution to using activities (e.g., Intermediate Maintenance Activities or Naval Bases) and within using activities (as a shipboard example, through SNAP*-controlled microcomputers linked with ethernets or fiber optics) is now a real possibility.

1.3.9 Extensive Improvement in Computer-Aided Design and Computer-Aided Engineering

Enormous technical strides have made possible greatly increased applications of Computer Aided Design (CAD), or, more generally, Computer Aided Engineering (CAE). As a result, much greater efficiency and speed in creating and updating TMs of greater comprehensibility with fewer errors are now possible, particularly involving preparation of TM graphics from design and installation drawings. TM graphics modification can be greatly simplified. Automated drawing repositories and automated TM repositories can be integrated.

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* SNAP refers to the Shipboard Non-Tactical ADP Program for achieving standardization of on-board non-tactical computers.

1.3.10 Computer-Based Integration of Logistics-Support Systems

A rapid increase over the last few years has occurred in implementation of computer-based, integrated, logistics-support systems aboard ship and in shore-based activities (e.g., SNAP and NALCOMIS [Naval Air Logistics Command Management Information System]). Experience exists and software can be developed for full integration of TM-related logistics functions such as TM electronic display, maintenance-action reporting, spare-parts ordering, and TM-deficiency and error report preparation.

The potential of these new capabilities to alleviate the frustrations experienced by Fleet technicians and others who must deal with deficiencies currently existing in the flow of Technical Information, has been made clearly apparent at the technical level throughout the Armed Forces. Thus, to the pressure caused by a marginally acceptable TI system has been added the expectation, based on operational tests, that electronic display of TI will unquestionably be the approach of the future, and the near future at that. The result is that there is a strong widespread desire at many technical levels and in the Fleet to achieve the electronic display of TI, and to discard paper systems as rapidly as possible. This expectation is supported and increased by the DOD-wide emphasis on CALS.

1.4 TECHNICAL CAPABILITIES OF ELECTRONIC DISPLAY SYSTEMS

Electronic display of TI offers intrinsic advantages to maintenance and system operation in a way never possible with paper; for example, the interactive nature of computer-based TI permits guidance on task performance tailored to the needs of an individual technician, in a way paper manuals cannot even

approach. The almost instant ability to call up information which might otherwise require shuffling of hundreds of pages of a paper manual is also of great value. Effortless branching to detailed explanations of poorly understood points, without loss of TI continuity, is another revolutionary capability.

Through electronic delivery, future Technical Manuals can be enhanced by display capabilities which will allow the viewer to increase the comprehensibility of an image of the system he is working on. These features can only be suggested in paper manuals; none can be realized as fully as with electronic delivery. Such graphics functions include:

a. _Perspective_ -- Objects may be shown in apparent depth (in three dimensions, or "3-D") with size, brightness, or surface cues included.

b. _Action_ -- Based on the now standard video-disc technology, action footage obtained by cinematic photography can be converted to digital form, integrated with more conventional text/graphics digital data, and freely displayed to supplement existing line-drawings or circuit-diagram graphics. This footage can show, for example, proper operation of some system that involves motion or the activity of a technician in maintaining or operating a system. (Such approaches, usually based on analog-signal recording, are already finding numerous applications in training.)

c. _Animation_ -- Apparent motion may be displayed with changes in position shown over successive frames; motion in linear or rotational paths can be shown clearly by this approach, as well as moving wave forms such as would be seen on an oscilloscope.

d. Zoom -- The user can blow up (expand) a portion of an image/object to show more detail, or reduce the magnification to obtain an overview of a larger portion of the image/object. Zoom thus provides the ability to move easily between views of different size.

e. Windowing -- Selected portions of one or more images may be displayed simultaneously on an existing frame of information. Thus, multiple windows containing information from different sources can be called by the user at the same time.

f. Scrolling/Panning -- Scrolling and panning permit movement of a window, or of a frame itself, to enable a technician to scan, for example, a large schematic when it is not possible to view the entire image at one time.

g. Overlay -- Overlay of multiple images and computer-generated information may be achieved either through software graphic routines or by specific hardware design. This capability permits the same graphic to be displayed with different sets of text.

1.5 APPLICATION OF TM AUTOMATION AT SUCCESSIVE LEVELS

TM-automation methods can be applied at three levels, cited below in order of increasing complexity and increasing payoff logistically.

a. Automation of Distribution, Storage, and Supply Processes Only. New Technical Manuals can be prepared by weapon-systems prime contractors in page-oriented

form and then scanned into digital form (either by the Contractor or by the Government) by simple raster scanning, providing a "bit map" of the text and graphics of each page of the Manual. All TM data can be interchanged, stored, and locally printed in digital form. The TM (or relevant parts of the TM) can be locally printed on-demand at the user technician's activity (e.g., aboard ship),providing him with a paper Manual identical to the TM created by the author, but with a less cumbersome logistics process in-between. This approach is particularly applicable to the digitization of existing bulky paper Manuals, since it requires no basic rework of the Manual content itself.

b. Incorporation of Computer-Manipulation Capability into Page-Oriented TMs. Existing or new paper Manuals formatted basically for paper display (page-oriented Manuals) can be similarly scanned into digital form, but with the use of Optical Character Recognition (OCR) equipment (or other "intelligent scanning" systems). This process provides an ASCII data stream, interpretable by a computer in terms of its information content (which a "bit map" is not). Graphics can be scanned into "vector form". Such digital information can be overlaid with computer-interpretable commands to permit location of specific items of Technical Information desired by the technician. These page-oriented Manuals can be displayed by a luminous-screen (e.g., cathode-ray-tube, backlit-liquid-crystal) device, or printed (in whole or in part) in the technician's own activity.

c. <u>Production of Frame-Oriented Technical Manuals for Electronic Presentation</u>. By use of an automated authoring system, a contractor can create a digitized text-graphics data stream designed from the outset for interactive electronic display (e.g., a frame-oriented Technical Manual) in which the user and the computer-controlled delivery system can interact extensively to provide improved access to specific items of Technical Information, and greatly enhanced TI comprehensibility. This approach also effects all logistics-chain-improvements implicit in the preceding a. and b. levels of automation (as well as others) but represents a longer-term approach, requiring a greater level of overall Navy-wide integration. A TM of this type is fundamentally "paperless"; or the frame-oriented display may be supplemented by an auxiliary laser printer for occasional use as an aid to effective employment of the screen-displayed information. This frame-oriented approach corresponds to the Type C Technical Manual in the terminology of the USAF AFTOMS Report[7], now in common use. In the AFTOMS terminology, a Type A Technical Manual is one which is delivered to the Government and used by the technician entirely in paper (page-oriented) form. A Type B Manual, as defined in Section 1-4 of the AFTOMS Report[7], consists of any <u>page-oriented</u> TM delivered by the Contractor in digital form. It would thus encompass either of the approaches given under automation levels a. or b., above.

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[7] USAF Systems Command CALS Publications: Air Force Technical Order Management System (AFTOMS), Automation Plan - Final Report, Feb 1988, DoD 856-88-3.

1.6 FLEET PAYOFFS FROM TM AUTOMATION

Installation of automated techniques at the levels cited as paragraphs 1.5 a. and 1.5 b. (acquisition or scanning of TMs into page-oriented digital form) can provide the following payoffs:

a. Reduction in weight and space demands for TM libraries, of particular importance aboard ship, with associated reduction in transportation and handling requirements at all points along the logistics chain.

b. Reduced backlog of Manuals on order by Fleet activities; reduced time required for a Fleet activity to obtain a needed Manual.

c. Reduction in time currently required of Fleet personnel in inserting Technical-Manual corrections or update pages, either as pen-and-ink corrections or change papers.

Acquisition of a totally integrated Automated Technical Information System, leading to interactive electronic TI delivery (Type C Manuals), as directed by the DEPSECDEF Memorandum of 1988[6], can provide the following additional advantages to the Fleet:

a. Reductions in maintenance errors and performance time in troubleshooting and corrective maintenance through greater information-presentation effectiveness, achievable by electronic display of properly designed TMs with optimal text-graphics interrelationships.

b. Reduction in false removal rates (i.e., in the number of unnecessary replacements of good components

mistakenly thought defective) through better troubleshooting presentations.

c. Increase in productivity of inexperienced personnel through provision of interactive TMs of improved comprehensibility and usability, augmented by backup information for use when required.

d. Reduction in training time required for the achievement of necessary maintenance and system-operation skills through TMs designed as more effective training aids.

e. Through overall TM system integration and automation, decreased weapon-system downtime as a result of immediate availability of the required TM, more rapid accessibility of specific information, more efficient identification and ordering of spare parts, and reduction in time required to complete associated paper work.

Full Navy-wide TM automation with the use of Type C Manuals will, moreover, provide better tools for program managers and support activities in acquiring and providing quality TMs to the Fleet when needed, resulting from an increased overall level of system efficiency through int g_ _ed automation.

1.7 NAVY TM AUTOMATION GOALS, STRATEGY, AND OBJECTIVES

Accordingly, the Navy is planning to reach, by 1998, the goal of implementing a Navy-wide system to acquire, manage, and utilize in digital form Technical Information required for weapon systems and equipment operation, maintenance, training, and logistic support. To achieve this goal, the Navy has

developed a strategy which requires a multi-pronged approach to problem solving, followed by phased implementation of proven automation capabilities, converging over the long term to a unified Navy-wide system. Specifically, to accomplish this strategy, the following objectives have been established:

a. System Acquisition Managers throughout the Navy will acquire effective TMs in standardized digital form and existing paper-based Technical Manuals will be converted.

b. The logistics-support infrastructure and the Fleet will be modernized to receive, store, control, update, replicate, distribute, and utilize digital TMs.

c. Specifications and standards to ensure transportability and interoperability of digital TMs throughout the Navy and DOD will be implemented.

d. The Fleet (both ships and shore facilities) will be equipped with electronic-delivery systems for interactive display of frame-oriented (Type C) automated Technical Manuals directly to user technicians.

2.0 SYSTEM CONSIDERATIONS FOR AUTOMATION OF TI
FOR WEAPON-SYSTEM SUPPORT

2.1 NEED FOR AN INTEGRATED SYSTEM

Provision of high-quality Technical Information to permit the Fleet to support its weapon systems requires careful balancing of a large number of related actions without which any single technological achievement could not be fully exploited. Some of these relationships, required (along with adequate Technical Information) in maintaining a weapon system for maximum operational availability, are diagrammed in Fig. 1.

In fact, it is the necessity to perform this highly interactive series of functions in a coordinated manner which has created the CALS requirement for fully integrated automation. Establishment of a single, coordinated process whereby the Navy can most effectively carry out all the actions required in the acquisition, control, and use of high-quality Technical Information will accordingly provide most effective Fleet System logistic support in all of its aspects.

2.2 AUTOMATED TM SYSTEM DESCRIPTION

To carry out most effectively the complex interactive functions involved in weapon-system support, the Navy must provide its Fleet technicians with Technical Information of the highest quality achievable. This TI must be both comprehensible and operationally suitable, designed to contribute to the accomplishment of all accompanying functions diagrammed in Fig. 1. To accomplish this requires establishment of an integrated system, involving dedicated staff and facilities, and using standardized hardware and software, which will support systems-acquisition managers,

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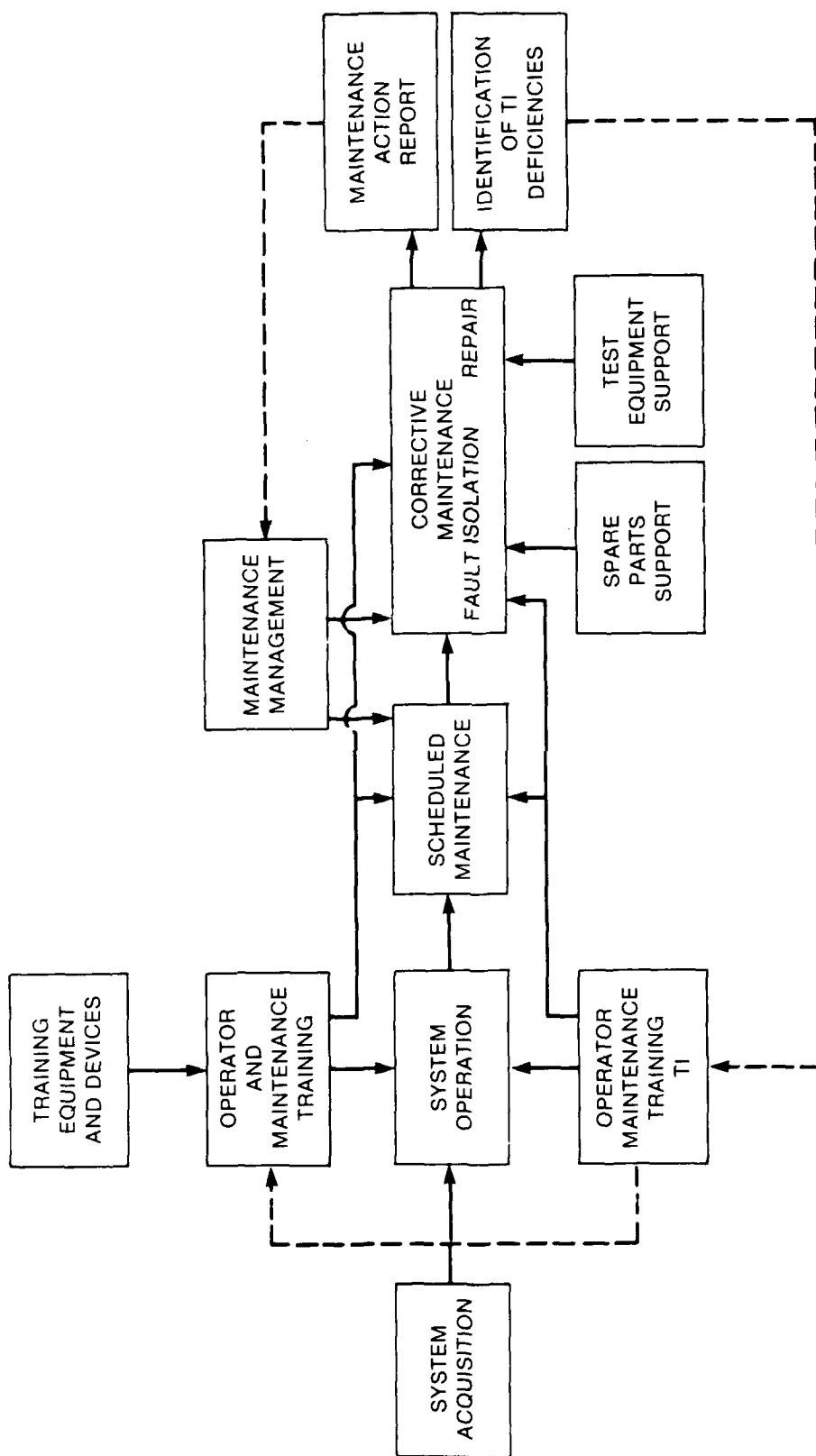
Fig. 1. Maintenance is a System problem.

logistic-support personnel, training activities, and the Fleet by carrying out or controlling the following processes:

a. Guided by standardized TM acquisition specifications, contractors will prepare digitized TMs capable of effective use by Fleet weapon-system technicians, logistic-support personnel, and trainers through interactive electronic information display.

b. The high quality of these digitized TMs, and their conformance to acquisition specifications, will be assured through contractor-performed QA, through TM verification, and through standardized automated acceptance testing in Navy in-house test facilities.

c. SYSCOM-dedicated facilities will store, update, distribute, and provide configuration management for TMs under their cognizance, and will assure that TMs are provided to end users in a timely manner. Shore-based and shipboard TM repositories will be fully automated and capable of interaction in real time with the SYSCOM TM-control activity.

d. Fleet and shore users will be provided with work-center and portable electronic-delivery devices to permit effective display of easily accessible information for system maintenance, operation, and logistic support.

2.3 SYSTEM IMPLICATIONS FOR ELECTRONIC DELIVERY OF TECHNICAL INFORMATION

The necessity to fit the process of TI electronic delivery into a carefully designed overall system for logistics support of weapons systems implies that the electronic-delivery system

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meet the following requirements so that TM delivery to the user can be effectively accomplished as part of a long, complex chain of functions operating sequentially. [Note that Navy policy requires that most of these considerations be addressed in the JLS (Integrated Logistics Support) analysis process, as described in MIL-STD-1388.]

a. The electronic-delivery system design must be consistent with the nature of the digitized Technical Information acquired and supported by the Service.

b. The electronic-delivery system must be designed to be operationally suitable; i.e., usable in the actual Fleet maintenance/operating environment where it will be needed. Human-factors and safety considerations must be taken into account.

c. The electronic-delivery system must be designed for high reliability and maintainability, and must be capable of efficient logistic support.

d. System design must be economically sound and technologically simple. Acquisition and support costs must be reasonable. Production must not require an excessively long time.

e. Maintenance procedures for the delivery devices themselves (planned and corrective) must be established, including the acquisition of maintenance TI for the delivery system itself.

f. A training program must be established, including Training TI for the delivery system itself.

g. System configuration-control procedures must be established along with configuration-control procedures for the system TI. Designated procuring activities must be chosen to assume technical control of the system; e.g., for preparation and control of acquisition specifications and for correction of identified deficiencies. Procedures must be established to assure correlation between update of system and update, replacement, and configuration management of the associated TI.

h. Logistic-support procedures (e.g., spare-parts ordering) must be established. Facilities and resources required to enable these procedures must be acquired.

Moreover, to make effective use of any system, especially one intended to support maintenance, a training program must be preplanned to make sure that technicians can use the system. In the Navy, such planning leads to preparation of the vital Navy Training Plan (NTP), part of the ILS process. Thus, curricula must be established, instructors designated, facilities made available, technician time set aside, and additional systems bought for the schools where such training will take place.

In addition to the ILS-related considerations cited above, which apply to most systems, the introduction of equipment intended for interactive TI presentation in support of maintenance imposes an even more difficult requirement: the requirement that all such presentation systems, from whatever source, display without error Technical Information which has been bought by a centralized procuring activity (the hardware system acquisition manager) using unified distribution

procedures, on a specific information-exchange medium, and with carefully standardized characteristics (i.e., standardization of the physical form of the digital data stream).

In general, the Services do not (and should not) create their own system-support Technical Information; they buy it from the prime contractor, who provides the hardware system the TI is intended to support. This acquisition is accomplished through the use of contractually applied specifications, and these specifications must be standardized, so that a wide variety of contractors can work toward the same end. Consequently, it is necessary to control the overall TI acquisition process in such a way as to assure that all electronic TI-display devices introduced into Service use are designed to handle TI generated in accordance with these specifications.

3.0 THE NAVY TECHNICAL INFORMATION PRESENTATION SYSTEM

3.1 SUMMARY OF THE NAVY TECHNICAL INFORMATION PRESENTATION PROGRAM

To assure that planning for TM improvements was carried out on an integrated, system basis, the Navy established the Navy Technical Information Presentation Program at the David Taylor Research Center.

Specific major objectives assigned to this effort were the following:

a. Develop and establish feasibility of a solution to the problems in the Fleet involving delivery and support of operating, maintenance, and training Technical Information;

b. Design and test an NTIP System consisting of an integrated set of procedures and equipments for acquisition, replication, distribution, use, update, and control of the operating, maintenance, and training Technical Information.

This RDT&E program accordingly has developed the concept for, and initiated operational tests of, an integrated System for Navy-wide TM automation, commensurate with the implications of Fig. 1, which is called NTIPS (Navy Technical Information Presentation System). The NTIPS approach, which has formed the conceptual basis for the Navy's long-term TI automation strategy, consists of six interlocked subsystems covering the entire Technical Manual cycle, as shown in Fig. 2. Implementation of each of the functional subsystems defined will require both technological and administrative innovations, in Industry and in the Navy, in order to achieve a smoothly operating procedure which begins with the expressed requirement
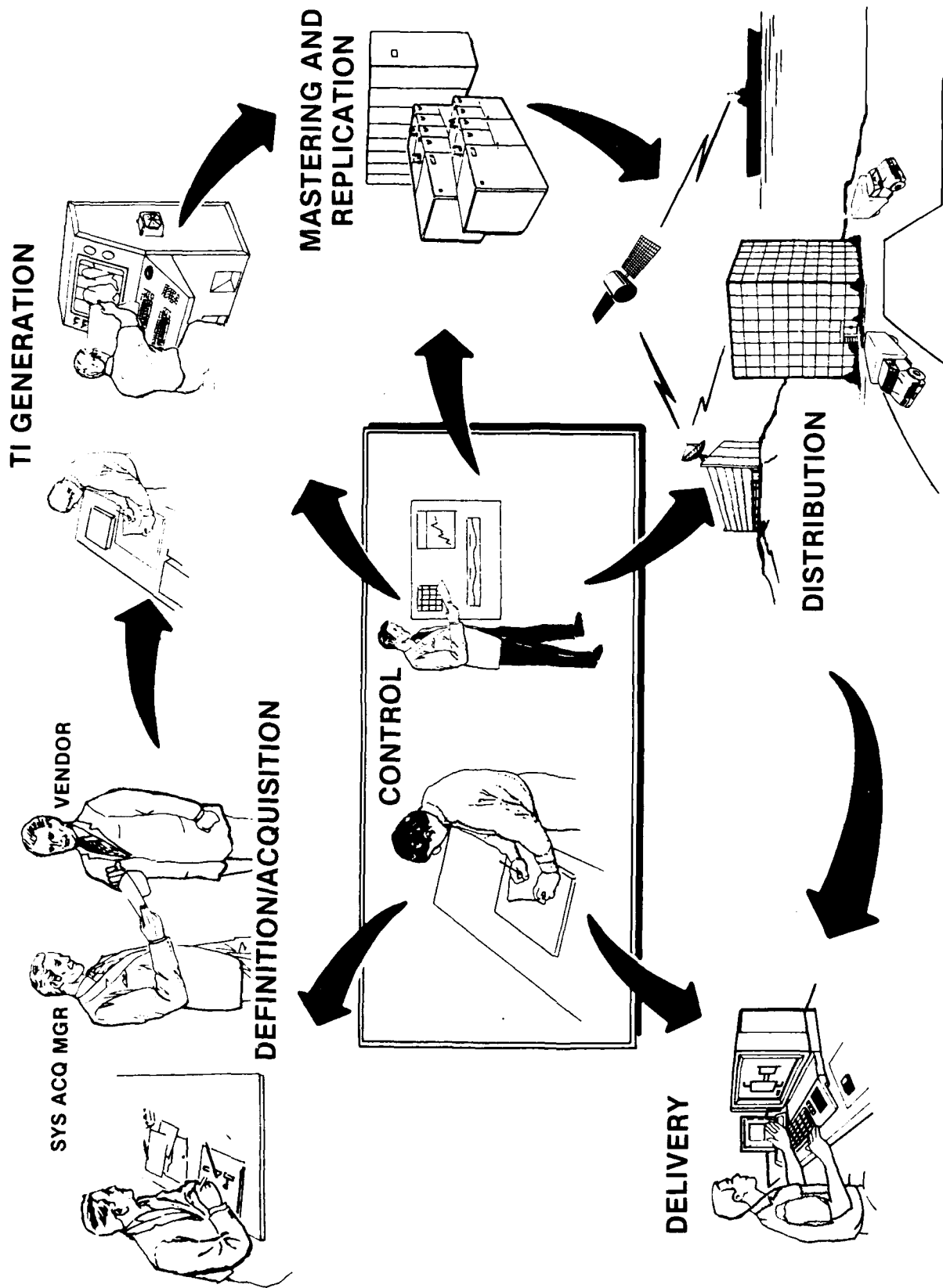
Fig. 2. The six subsystems of NTIPS. (The diagram shows the flow of technical information from the Definition/Acquisition phase through Mastering, Replication, Distribution, and Electronic Delivery. The overall system Control function is vital to continued function of the TM process.)

for weapon-system logistic-support Technical Information, and leads to efficient Fleet support of the weapon system through electronic delivery of the required TI.

SECNAV Instruction 5219.2A, 11 May 1987[2], directed that NTIPS be developed and implemented within the Navy Material Establishment.

3.2 NTIPS FUNCTIONAL DEFINITION

The NTIPS effort has carefully documented proposed approaches to achieving the integrated stream of capabilities shown in Fig. 2, and has defined in detail the interrelationships among the functions. These results have been based on approximately a decade of RDT&E effort, in which the following tasks were accomplished and results disseminated:

a. Fleet needs for TMs and improvement in TM-presentation modes were analyzed through observation and examination of Fleet-maintenance procedures and through the use of questionnaires.

b. Human-factors analyses of comprehensibility factors and optimal display designs were carried out. For example, a study was performed to establish the requirements for constructing a comprehensible frame-oriented display of text and graphics. See Section 3.3.

c. The NTIPS project continually monitored, evaluated, and analyzed the rapidly advancing Technical-Information handling and presentation technology, both in Industry and in work supported by the other Services.

d. The Navy Technical Information Presentation System was developed and defined. Functions of individual subsystems were worked out in detail; interfaces were elaborated; technological, procedural, and administrative requirements for acquisition of this fully automated, integrated system were identified.

e. Fleet tests (air and surface) were performed using Technical Information designed for greater comprehensibility and suitability for electronic display, to compare the performance effectiveness of maintenance technicians using electronic display of frame-oriented TI as compared with their performance effectiveness when using the conventional paper Manuals. Results of these tests are summarized in Section 3.4.

3.3 COMPREHENSIBILITY OF ELECTRONIC DISPLAY OF FRAME-ORIENTED TECHNICAL INFORMATION

The NTIPS effort has clearly shown that presentation of Technical Information by means of a luminous screen requires formatting and sequencing of the text and graphics material in a manner different from that which is common with paper Technical Manuals (which are themselves not always arranged or formatted optimally). The principles governing screen presentation of Technical Information for greatest comprehensibility and efficiency are not well understood at this time. Much analysis and, in particular, operational testing remains to be carried out.

Some principles are clear, however. With near-term technology, display screens, particularly for portable delivery devices, are likely to have display areas which are

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significantly smaller than 8.5" x 11" paper pages. In such cases, the individual increments of Technical Information (individual frames) must be kept far simpler than they are in conventional paper TMs. Comparison of Fig. 3 (a typical page of existing paper Technical Manuals) with Fig. 4, a text-graphics module designed for frame-oriented presentation of the indicated portion of the same information, will illustrate the point. Repeated operational experience has shown that information which is formatted for paper-page presentation is generally unsuitable for screen presentation. User irritation and subsequent rejection of page-formatted material displayed in this fashion is of frequent occurrence.

3.4 FIELD TESTS OF TECHNICAL INFORMATION DESIGNED FOR ELECTRONIC DISPLAY

Lessons learned from NTIPS RDT&E efforts (and from observations of the efforts of the other Services and of Industry) were incorporated into preparations for two major Fleet tests, involving interactive, electronically presented, troubleshooting and corrective-maintenance Technical Information, for both an air system (the rudder-trim system of the F-14A aircraft) and a shipboard system (the AN/SPA-25D radar repeater).

The tests showed that an overwhelming majority of enlisted technicians find electronic presentation of Technical Information entirely acceptable, and look forward enthusiastically to its wide introduction into the Fleet.

These Fleet tests also provided considerable guidance as to areas needing improvement; for example, improvements were required of graphics and of the human-factors aspects of the delivery device/user interface (e.g., in response time and information accessibility).

loose. Position the deflection coil (36) over the neck of the crt and carefully lower the deflection coil to its mounting position. Adjust the deflection coil so that terminals 1 and 2 are aligned with the 0-degree mark on the azimuth scale. Check that there is at least a 1/16-inch clearance from the point of contact with the crt. (The crt glass is uneven, therefore, a minimum of 1/16-inch clearance must be maintained from the highest peak of glass.) Secure the deflection coil (36) with the three deflection coil clamps (33) with their screws and lockwashers. While tightening the screws verify that the deflection coil does not press against the neck of the crt and there is a 1/16-inch clearance between the crt high point and the deflection coil. If necessary, loosen the deflection coil and bracket assembly mounting screws, lockwashers, and flat washers (44) and adjust the deflection coil and bracket assembly (45) and then tighten the mounting screws.

7. Complete the installation and adjustment of the deflection coil by referring to steps 8 through 76 of paragraph 6-38b. Install those assemblies, support brackets, and parts removed to gain access to the deflection coil.

6-37. 1L3 TUBE FOCUSING COIL. To remove, install, and adjust the tube focusing coil (focusing coil) proceed as follows:

1. Remove the focusing coil (41, figure 6-2) by referring to the procedure described in steps 1 through 22 of paragraph 6-38a. Remove only those assemblies, support brackets, and parts necessary to gain access to the focusing coil.

2. Remove the three focusing coil lateral adjustment screws, lockwashers, and flat washers (38) and carefully remove the focusing coil (41).

3. Remove the three screws, lockwashers, flat washers, angle brackets, and nuts that hold the focusing coil to the focus coil plate.

4. Identify, tag, and unsolder the leads from the defective focusing coil.

5. Solder the leads to the appropriate terminals on a new focusing coil.

6. Position the focusing coil on the focus coil plate and install the mounting screws, lockwashers, flat washers, angle brackets, and nuts. Align the angle brackets before tightening the screws and nuts.

7. Position the focusing coil over the neck of the crt with the two soldering terminals in alignment with the 180-degree mark on the azimuth scale. Carefully position the focusing coil on the bracket and install the three focusing coil lateral adjustment screws, lockwashers, and flat washers (38) but do not tighten the screws. Check that the focusing coil is physically centered around the neck of the crt and then tighten the three focusing coil lateral adjustment screws (38).

8. Complete the installation and adjustment of the focusing coil by referring to the procedure described in steps 14 through 76 of paragraph 6-38b. Install those assemblies, support brackets and parts removed to gain access to the focusing coil.

6-38. 1V1 CATHODE RAY TUBE (figure 6-2). To remove, install, and adjust cathode ray tube (crt), proceed as follows:

Fig. 3. A page of unrelieved text from an existing paper technical manual. (This text requires referencing to a number of other sources.)

4-2.1. SI5. REMOVE SHIELDS AND FOCUSING COIL

5. Loosen three lateral adjustment screws (4), lockwashers (5) and flat washers (6). Remove focusing coil 1L3 (7) with focus coil plate (8) attached.

6. Remove three screws (9), angle brackets (10), lockwashers (11), and nuts (12). Remove focus coil plate (8) from focusing coil 1L3 (7).

7. Identify, tag, and unsolder the leads from focusing coil 1L3 (7).

| NEXT PAGE | BACK PAGE | | | COPY PAGE | HELP | STOP/EXIT |
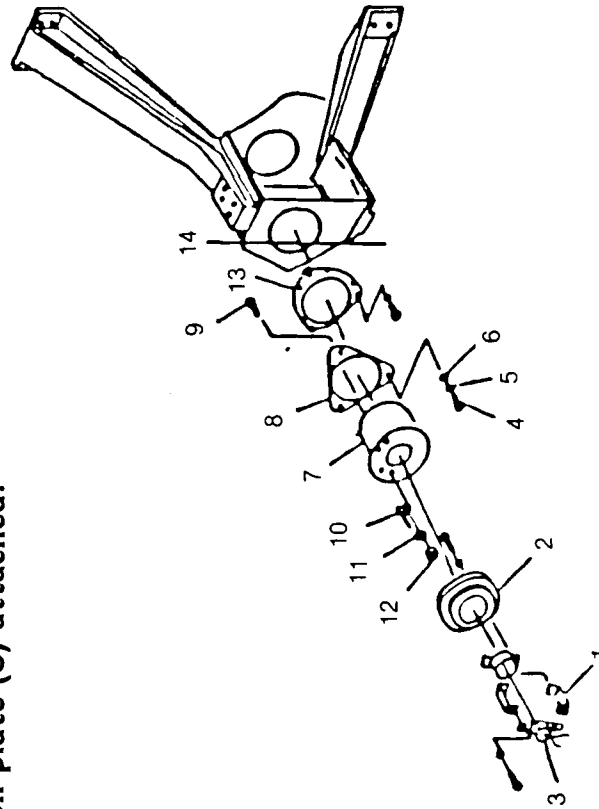
Fig. 4. A text-graphics module displaying the same information as that marked on Fig. 3. (This frame is designed for electronic delivery; an entire frame presenting three of the many textual procedures contained on a single page of a paper manual.)

3.4.1 F-14A Air-System Field Test

The air-system operational test[8] was conducted at the
Naval Air Station, Miramar, employing active-duty enlisted
technicians (AEs) from 10 VF squadrons, the Air Intermediate
Maintenance Division (AIMD), and the Naval Air Maintenance
Training Detachment (NAMTRADET). Several types of
troubleshooting and corrective-maintenance Technical
Information, in paper form and electronically delivered, were
used by the technicians to carry out assigned fault-isolation
and remove-and-replace tasks in an aircraft hangar with an
electronic-display device mounted on a workstand. Tests of
troubleshooting TI involved insertion of faults into an
operational aircraft and performance of fault-isolation with
conventional TI and with electronically presented TI, using 24
fighter-squadron maintenance personnel as test subjects.

Results showed that electronic presentation of properly
designed TI is of great benefit to the end-user under
operational conditions in the following two major ways:

a. Maintenance errors were reduced.

b. Performance of untrained and partially trained
   technicians was greatly improved (often becoming
   superior to that of experienced personnel using
   conventional paper-based TMs).

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8   Fuller, Joseph J.; Theodore J. Post; and Anne S. Mavor.
    Test and Evaluation of the Navy Technical Information
    Presentation System (NTIPS), F-14A Field Test Results.
    DTRC-88-036, September 1988.

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Specific results were as follows:

- 12 out of 12 test subjects located the fault using electronically delivered TI. (Only 5 out of 12 were successful with paper TI.)

- In Remove/Replace/Checkout procedures, there were 35% fewer errors by inexperienced technicians who used electronically delivered TI than those who used paper TI.

- 90% (18 out of 20) of the technicians preferred electronically presented TI.

3.4.2 AN/SPA-25D Ship-System Field Test

Similar tests using automated Technical Information were also performed[9] for the AN/SPA-25D shipboard radar repeater in a maintenance shop at the Naval Sea Combat Systems Engineering Station in Norfolk, Virginia. Test subjects were 24 active-duty enlisted Electronic Technicians (ETs) designated for the test by Commander, Naval Surface Forces, U.S. Atlantic Fleet (COMNAVSURFLANT), divided into an experienced and an inexperienced group. Troubleshooting and corrective-maintenance tasks were performed (with faults introduced into operational equipment), using both paper-based Technical Information and electronically-presented TI. Results confirmed those of the air-system tests completely.

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9 Fuller, Joseph J.; Raymond P. LeBeau; Anne S. Mavor; Theodore J. Post; and Charles S. Sawyer. Test and Evaluation of The Navy Technical Information Presentation System (NTIPS), AN/SPA-25D Test Results. DTRC-88-035, September 1988.

Specifically[9]:

- With electronically delivered TI, <u>all</u> <u>technicians</u> (11 experienced and 13 inexperienced) correctly isolated the fault. (With paper TI, <u>only</u> <u>58%</u> <u>of</u> <u>the</u> <u>technicians</u>, 7 inexperienced and 7 experienced, were able to isolate the fault without help from test monitors.)

- Troubleshooting time with electronic delivery was 24% faster than with conventional paper TM.

- 92% of the technicians preferred electronically presented TI.

3.5 DRAFT SPECIFICATIONS FOR AUTOMATED TECHNICAL MANUAL (ATM) AND ELECTRONIC DELIVERY DEVICE ACQUISITION

Based on NTIPS analyses and tests to date, including, particularly, the two extensive operational field tests, the NTIPS Office has recently completed and distributed for comment and DOD standardization a series of four draft specifications[10-13] which could be used by a System Acquisition Manager to buy, on

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10 Draft Specification MIL-M-ATM. Manual, Technical. Content, Format, and Style Requirements for Electronically Delivered Technical Information to Support Troubleshooting and Corrective Maintenance of Weapon Systems. 31 October 1988 (Prepared by DTRC).

11 Draft Specification MIL-D-TIEDS. Electronic Delivery System for Automated Technical Information. 31 October 1988 (prepared by DTRC).

12 Draft Specification MIL-T-ATIQA. Quality Assurance (QA) Program Requirements for Automated Technical Information (ATI). 31 October 1988 (prepared by DTRC).

13 Draft Specification MIL-M-PCDDS Technical Manual; Physical Characteristics of the Digital Data Stream for Delivery to Government. 31 October 1988 (prepared by DTRC).

a prototype basis, digitized Technical Manuals for troubleshooting and for corrective maintenance of a shipboard or shorebased weapon system or other equipment.

The specifications for the automated Technical Manual product, and for the Electronic Delivery System, were:

MIL-M-ATM.   Manual, Technical. Content, Format, and Style Requirements for Electronically Delivered Technical Information to Support Troubleshooting and Corrective Maintenance of Weapon Systems. 31 October 1988 (prepared by DTRC)[10].

MIL-D-TIEDS.   Electronic Delivery System for Automated Technical Information. 31 October 1988 (prepared by DTRC)[11.]

These specifications were supplemented by a draft specification describing a proposed QA procedure under which the automated authoring of the ATM should be carried out:

MIL-T-ATIQA.   Quality Assurance (QA) Program Requirements for Automated Technical Information (ATI). 31 October 1988 (prepared by DTRC)[12].

This specification calls for development of a Technical Information Quality Assurance Program Plan (TIQAPP) which, when approved by the Government, would form part of the contract specifications for conduct (by the contractor) of the QA for the ATM. This specification also summarizes proposed Government acceptance-test procedures for evaluating the digital data stream offered by the contractor which contains the Technical Manual.

The proposed detailed physical characteristics of this contractor-generated digital data stream are described in the Draft Specification:

MIL-M-PCDDS Technical Manual; Physical Characteristics of the Digital Data Stream for Delivery to Government. 31 October 1988 (prepared by DTRC)[13].

3.6 DAVID TAYLOR RESEARCH CENTER (DTRC) ADVANCED TECHNOLOGY EVALUATION LABORATORY

DTRC has established a laboratory and test facility for the evaluation of emerging information-processing technology for Navy TM-automation purposes and for other CALS-related functions. Specific tasks assigned to this facility include:

a. Evaluation of candidate products for Navy use;

b. Prototyping of systems to be used for standards development;

c. Centralized test and control of proposed standard Government-owned software;

d. Integration and development of selected systems.

This facility is designed to maximize Navy use of Industry-developed ATM technology, and will serve as the Navy's technologically oriented focal point for Navy/Industry liaison in the TM automation area.

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Any development effort that the Navy may take in the ATM area will be carried out only where a specific need exists in the acquisition of a Navy-wide TM system to which no Industrial development effort is directed.

4.0 FUNCTIONS AND DESCRIPTION OF AN ELECTRONIC DELIVERY SYSTEM

The following description of a proposed electronic delivery system is extracted from the NTIPS specifications and reflects research, development, test, and evaluation performed to date by the NTIPS program.

4.1 FUNCTIONAL REQUIREMENTS

The purpose of the Technical Information electronic-delivery system is to effect all local storage, transmission, and presentation of digital TI to users (e.g., maintenance technicians) within shipboard or shore-based environments, employing all-electronic media. The system must meet the following general design objectives:

a. It must permit timely interactive user access to complete, current, and accurate TI.

b. It must present TI to the user in a manner that facilitates high-quality user performance or learning within the technical job environment, through an effective man-machine interface.

c. It must make possible the collection, storage, and transmission of all user-originated information (e.g., TI deficiency reports, maintenance-action reports, and parts requests), which must be transmitted to centralized activities for processing.

4.2 DESIGN REQUIREMENTS

To accomplish the functions listed above, the delivery system must meet the following design requirements:

a. It must be modular. Design and interrelationships among the functional modules must permit adaptation of the configuration to meet the requirements for autonomous TI delivery within differing work environments.

b. It must allow the efficient management of large-volume TI data bases and, consequently, provide a timely flow of digital TI from local TI storage (library or internal) to the user.

c. It must be designed to interact with test equipment by providing interfaces with BITE, ATE, and special-purpose test equipment. It must be capable of presenting interactively an intrinsic automated computer-controlled troubleshooting approach.

d. It must be able to operate reliably within the different physical environments where Navy maintenance and system operation are carried out, including shipboard environments, and must provide TI required for job performance under the actual maintenance conditions in which the user works.

e. The electronic delivery devices must be able to operate in either on-line or off-line mode. The overall delivery system must contain portable, stand-alone delivery devices which can be moved to remote job sites.

f. The electronic delivery devices must be capable of presenting TI to the user through optimal electronic-display features (e.g., text-graphics modules, animation, zoom, scroll, windowing) which support job-performance and the transfer of Technical Information to the user.

g. The storage media must provide sufficient data-storage capacity to accommodate the TI requirement of all work centers within a ship or shore base.

h. Data-transmission rates of the electronic-delivery system communication channels must be sufficient to support the data-access speed requirements of TI users.

i. It must provide for data security through the control of data-base access and the control of physical security of all components.

j. It must be defined to a level of detail which will permit the establishment of requirements for the design, development, fabrication, assembly, installation, upgrading, and quality-assurance testing of the system.

k. The system must employ technologies which will be available and cost-effective during the projected implementation time frame (early 1990s).

4.3 SYSTEM DESCRIPTION

As described in the draft specification MIL-D-TIEDS[11], and in a DTNSRDC Technical Memorandum by Jorgensen and Fuller*, the electronic-delivery system will comprise the following units:

4.3.1 The Work Center Device

A bench-mounted, transportable (but not necessarily portable) device must be provided with sufficient information-handling capability to permit system support for every system on the ship or station (e.g., with the Technical Information recorded on multiple 5¼" digital optical discs). All of this information need not be on-line, but any required data must be capable of being retrieved immediately by a variety of call methods. The work-center device must be provided with, and capable of communicating through, a suitable data buss to the central ADP or logistics-communication system of the ship or station (e.g., the SNAP system), and to a centralized TM information library (or libraries) for the ship or station if such capabilities are maintained separately. However, in its function of presenting TI to system-maintenance or system-operation technicians, a work-center device must be capable of entirely autonomous operation. It must be capable of downloading designated TI to a portable delivery device which will be detached and carried to a separate work site. The work-center device must be capable of constituting a node of a Local Area Network (LAN) which permits intercommunications among the delivery devices (and performs other functions). For example, it must be able to function as a node of a LAN so constructed that TM information contained on a disc in a

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* Jorgensen, Eric L.; and Joseph J. Fuller. Navy Technical Information Presentation System (NTIPS) Design Characteristics for Electronic Delivery Systems DTNSRDC/TM-18-8 7/10 July 1987.

delivery device in one work center can be viewed on a delivery
device in another work center (another node on the LAN) if
needed.

The work-center electronic-delivery device is thus
required to perform three functions:

a. A Library function; i.e., storage of a wide variety of
   Technical Manual information to which a technician can
   obtain immediate access.   If the volume of TM
   information involved requires it, the work-center
   device can be provided with peripheral storage
   capability (e.g., hard-disc, CD/ROM, or WORM, as
   required), to which the device is permanently hard-
   wired, and on which it can draw as required;

b. Display of Technical Manual information (text and
   graphics) to a Fleet technician as required;

c. Communication with other information systems of the
   ship or station, with a printer, with a portable
   electronic-delivery device, and with other work-center
   electronic-delivery devices constituting the nodes of
   a Local Area Network.

4.3.2 The Portable Delivery Device

The Portable Delivery Device will consist of an easily
carried device which presents TI in electronically displayable
form to a technician who must, for example, repair a system at
a site remote from the work center. This portable device will
normally contain digital text-graphics information (including
both troubleshooting and corrective-maintenance information)
which has been downloaded for the specific maintenance task at

hand from a work-center device. The TI involved must be totally self-sufficient and the device must be able to handle as much as the equivalent of several hundred pages of a conventional Technical Manual. Once the specific maintenance effort is completed, the TI data involved will be disposed of or destroyed.

4.3.3 The Embedded Device

The Embedded Device will perform in a manner essentially equivalent to that of the portable delivery device, but will be permanently located in conjunction with those (relatively few) shipboard or air-station systems for which maintenance is always carried out in some specific compartment or location, where a large number of complex system components are operated (e.g., a ship-performance monitoring system). TI sufficient for all maintenance or operating requirements, downloaded from a work-center device, will be maintained on some non-volatile, self-contained memory medium (e.g., a hard disc) on a continuing basis.

4.3.4 An Associated Printer

Although the process of providing digitized Technical Information for electronic display is designed to eliminate reliance on a paper medium, each work-center device will be supplemented by a compatible printer capable of handling up to "B" size drawings (11" x 17") to permit generation of a paper copy of some specific piece of TI which may be required by an individual technician for performance of a specific task (e.g., a circuit diagram or a check list). Such material will in general be limited, used on a temporary basis, and discarded when the particular job is finished. Requirements for this laser printer, which may be a commercial device, will probably not be covered in detail by a military specification.

These four types of units are shown schematically in Fig. 5. Detailed (proposed) functional and physical requirements are summarized in Appendix A [which has been taken from the DTNSRDC Technical Memorandum by Fuller and Jorgensen cited in Section 4.3.1].

4.4 SUMMARY OF NAVY USER ENVIRONMENTS

The electronic delivery system must provide Technical Information in all Navy user environments. The Navy maintains its weapon systems at three levels: organizational, intermediate, and depot. The electronic delivery system must also operate in training environments.

4.4.1 Organizational Maintenance

Organizational Maintenance is carried out primarily on-board ship or at a Naval Air Station or other forward aircraft-operating station.

4.4.1.1 Shipboard Organizational Maintenance

Implies the existence of well-equipped work centers, with the environment generally adequately controlled (except occasionally for vibration or shock). A considerable amount of onboard maintenance is carried out in compartments where the weapon system regularly operates.

Shipboard maintenance of HM&E (Hull, Mechanical, and Electrical) equipment; i.e., those systems involving the ship itself (propulsion, power, steering, water, etc.) must often be done outside of the hull envelope, or in ship compartments where the equipment is located. In the great majority of cases, this maintenance may be carried out with the use of Technical Information downloaded into a portable delivery device. In some cases, shipboard maintenance must be performed in locations which are less amenable to use of electronic

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EMBEDDED DISPLAY

LASER PRINTER

PORTABLE DELIVERY DEVICE

WORK CENTER DEVICE

FRAME DISPLAY

CD-ROM

FLOPPY DRIVE

HARD DISK
WORM DISK

KEYBOARD
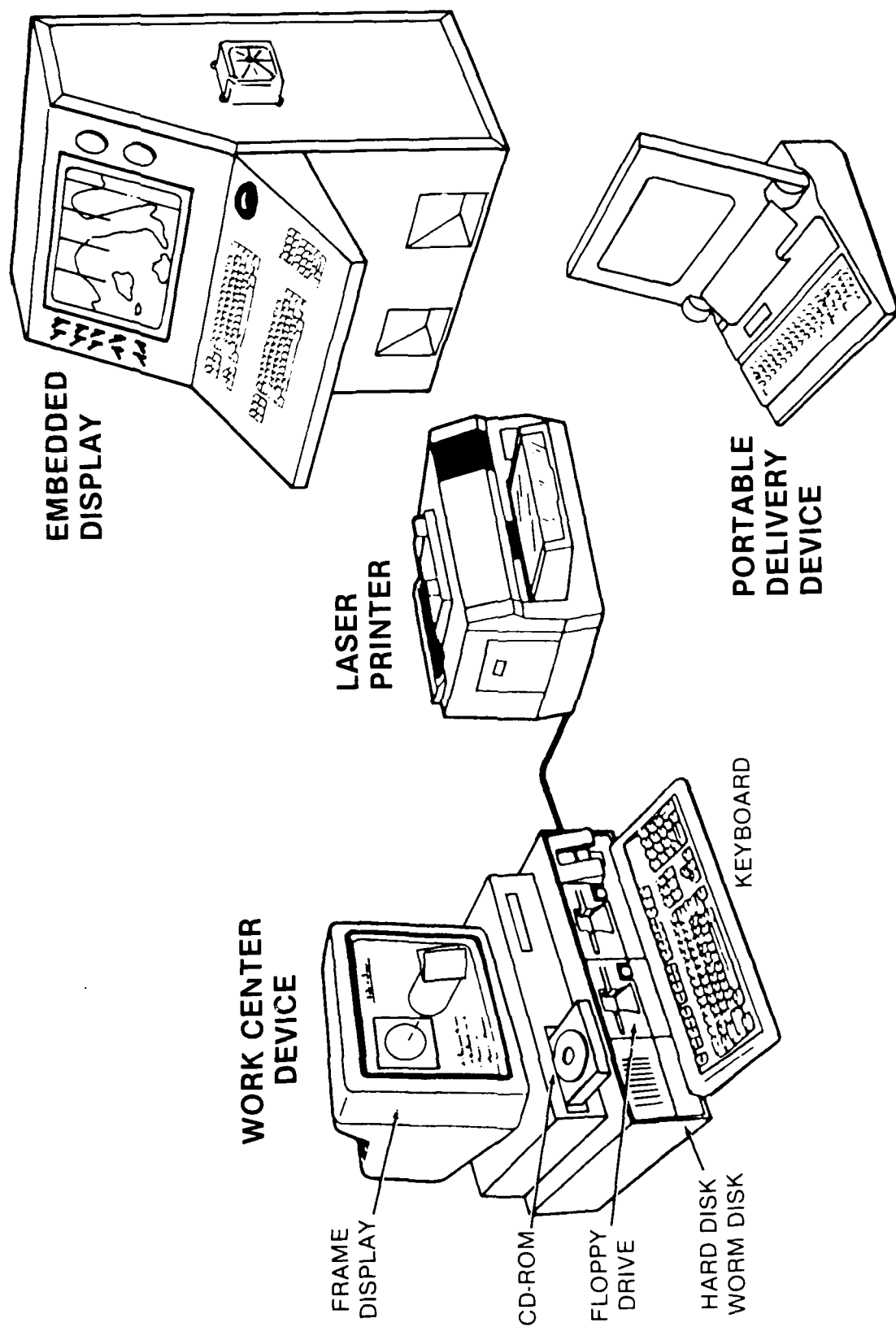
Fig. 5. Constituents of a shipboard or shorebased electronic delivery system.

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equipment or where it is physically difficult to operate. In such rare cases, however, requirements for use of a conventional TM during a maintenance task would be unlikely. Procedures for maintenance in these environments are generally learned by training or experience prior to performance of the task. As an example, consider flight-deck maintenance on an aircraft carrier. It would be extremely unusual for a technician to use a TM during flight operations; if corrective maintenance of any degree of complexity were required, the aircraft would be returned to the environmentally controlled hangar deck.

Note: The need to use TMs for outside maintenance tasks (e.g., in bad weather, at night, in the mud, etc.), which may represent real requirements of the USMC and the Army, does not generally represent a real problem for the Navy, which performs most maintenance requiring a TM in an enclosed environment. Although, as noted above, maintenance and repair tasks sometimes are performed in extremely bad shipboard environments (ships' bilges, fire-rooms, flooded compartments), technicians would rarely use TMs during such conditions.

4.4.1.2 Aircraft Organizational Maintenance

Aircraft maintenance at shorebased aircraft-operating bases is usually performed in hangars or hangar-shops with reasonably well controlled environments, supplemented with occasional outside (flightline) maintenance when environmental conditions (weather, temperature, light) permit. In such cases, electronically delivered TMs could be used either with portable delivery devices or with larger work-center devices mounted on wheeled carts. If environmental conditions deteriorate, maintenance is stopped or the aircraft is moved into a hangar or other protected surrounding. Inability to use

an electronically delivered TM would almost never be the limiting factor under such circumstances. As noted in Section 4.4.1.1, maintenance of aircraft on-board aircraft carriers is usually performed on the protected, environmentally controlled hangar deck.

4.4.2 Intermediate Maintenance

Both the ship Navy and the aircraft Navy operate Intermediate Maintenance facilities, called, for example, the AIMD (Aircraft Intermediate Maintenance Department) of a Naval Air Station or a SIMA (Shore Intermediate Maintenance Activity) for ship-system repair at a Naval Base. Intermediate Maintenance facilities, both ship-based and shorebased, are well equipped (in terms of test and other repair equipment) and are environmentally controlled. The Navy's tenders (shipbased maintenance shops, elaborately equipped) are Intermediate Maintenance facilities which may be moved from place to place, but are almost always moored in calm water when in use. Intermediate Maintenance facilities are staffed with (or have available to them) more senior and experienced technicians than would be found in the average operational unit.

4.4.3 Depot Maintenance

Naval Aviation Depots (NAVAVNDEPOTs) and the Naval Shipyards (NSYs) constitute the Depot Maintenance facilities of the Navy. Such facilities are designed for maintenance under ideal conditions of environment and physical maintenance support, and can completely rebuild major weapon systems. They are staffed primarily with civilian employees of extensive skill, training, and experience.

Such facilities, and to a slightly lesser extent the Navy's Intermediate Maintenance facilities, offer ideal environments for the use of electronically displayed Technical

Manuals for system maintenance. In fact, because of the complex nature of the repair tasks performed and the generally high level of training and experience of the technicians, special Depot Maintenance manuals could be far more sophisticated (i.e., with less reliance on detailed presentation of procedures) than those for Organizational Maintenance, and could provide an increased level of computer-controlled interactivity between technicians and the technical data base which is available for a given system. (See Section 5.2.3.)

4.4.4 Training Activities

Navy Schools (both surface and air), with and without hands-on equipment (which may be computer-stimulated) represent an additional using environment for TMs (which are the textbooks for system-related training). Such facilities normally provide interior office-like environments, or when complex simulators and the like form a part of the training equipment, such facilities are even more carefully controlled environmentally.

The Navy conducts some training which uses TMs on- board ship, but this is relatively uncommon. In such a case, however, a normal shipboard environment would be involved.

4.5 HARDWARE CONSIDERATIONS

In any maintenance facility, space is limited. Even a bench-mounted (work-center) electronic-delivery device must be designed in as small a package as possible, commensurate with its performance of the complex functions required of it. At the same time, however, the display screen should be made as large as possible, commensurate with the structure of the Technical Information, the memory capacity of the delivery

device, and the complexity of the electronics that support the screen. The work-center device must be capable of accepting, assimilating, and displaying large quantities of digitized information written on optical (e.g., WORM) disc, but it must also be structured to contain up to 20 megabytes of internal random-access high-speed memory, with access to another 100 megabytes of random-access hard disc, which, however, can be packaged as a separate module. Accordingly, whereas the front cross-section of such a device should be limited in size to about 2.5 x 1.5 feet, the screen size should have an active display area of at least 7 x 10 inches, and more if possible. For the work-center device, weight is of relatively low importance; a weight of as much as 35 lb would be acceptable.

Environmental requirements for shipboard and shorebased electronic equipment, which all versions of the delivery device would be required to meet, are expressed in Specification MIL-E-16400G, Electronic, Interior Communication, and Navigation Equipment, Naval Ship and Shore, General Specifications for, 1 Dec 1976. This Specification contains stringent requirements with respect to such environmental factors as shock and vibration, salt spray, temperature, and humidity.

The portable electronic delivery device must be smaller, lighter, and more rugged than the work-center device. Its size should not exceed about 18" x 12" x 4", and it should weigh no more than about 10 lb, in addition to an optional detachable 5-lb battery pack. It must be designed so that it can be carried to a work location remote from the work center, including up and down ladders. It must be designed to operate in a wide variety of ambient light, temperature, and humidity levels, and must come quickly to full operating condition even after having been switched off for months.

4.6   SOFTWARE CONSIDERATIONS

Design of a TM electronic-delivery device implies careful integration of a hardware device and an operating software program (which interprets the various items of digitized TI to the user). The software is as important as the hardware, and must be maintained as carefully as the hardware portion of the system.

A primary software consideration in designing the operating system of the electronic delivery device is the establishment of absolute correspondence between the logical structure of the digitalized Technical Information, with its carefully constructed calling sequences and interrelationships among specific frames of information, and the governing software of the delivery device. This correspondence is necessary to assure that the Technical Information is displayed to the user in precisely the manner intended.

The electronic-delivery system will consist of a computer-controlled device which displays the required Technical Information by means of a luminous screen either in a pre-ordered sequence or in random-access increments as called for by the user; e.g., a maintenance technician. Such calling sequences, to be pre-established by the author and exercised by the user, will include branching to cited references, requests for more detailed information (e.g., HELP), accessing parts information that may be needed, etc. (The author-established calling sequences may be supplemented by user-established calling sequences to improve a technician's ability to access whatever information he may consider needed.) Thus, the primary function of the delivery system is to provide the user with the capability to call and observe selected increments of information from a highly structured data base,

which has been carefully pre-established and ordered by the TM author. The Technical Manuals to be used by this electronic-delivery system must accordingly be so constructed as to be fully compatible with the operating software of the delivery device, and must be tested on such a delivery device (i.e., on the actual Government-specified device which will be used in the Fleet) prior to acceptance by the Government. Thus, the acquisition specifications for the electronic-delivery device, and for the digitized Technical Information to be used with it [as described in detail in the proposed MIL-M-ATM[10]] must be considered together. Each requirement cited in the Automated Technical Manual specification (to which the TM author must conform) must have its counterpart in the electronic-delivery system specification (which requires a capability the system designer must provide so that each TM capability provided by the author can be realized in displaying Technical Information to the user).

4.6.1 Content of the Digital Data Stream

Specifically, the Technical Manual to be displayed to the using technician by the electronic-delivery system will consist of a highly structured series of records containing:

a. text, text-graphics modules, and graphics, interspersed with

b. standardized software, containing commands which control the sequencing of the information presented;

c. included software which permits the exercise of a number of special functions in terms of display of the TI (e.g., NEXT, BACK, HELP, COMMENT, SCROLL, ZOOM, WINDOW, and others); and

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d. included software which provides calling sequences from one frame to any other desired frame. The TM author may base these calling sequences on a number of algorithms; for example, he may link items of information by the use of frame numbers so that exercise of a "Next" command calls a required frame; or he may use pre-established content-related frame labels, requiring that the using technician key in information which initiates the call (e.g., a subsystem name or part number).

Each frame will be stored either as a single file (pure text or pure graphics) or as multiple overlaid files (for text-graphics modules). In the latter case, the files will be linked so that, when the frame is called, the text and the graphics constituting the frame are displayed simultaneously. By this method, a single graphic which applies to many frames (as in a long sequence of maintenance steps describing an action at a single location) need be stored only once, but may be displayed in text-graphics-module form with a sequence of short text increments on a number of sequential frames. This file structure is, of course, dictated by the requirements for the Automated Technical Manual itself, and will have been established during the authoring process.

The author of the TM will have associated with each file one or more alphanumeric designators to show sequencing and to be used in calling algorithms. (These designators serve in effect as "file names".) The actual software which effects the calling commands for specific frames must be part of the operating software of the Display System and will not be part of the ATM itself; as noted, the Technical Manual will contain only content records, each associated with one or more specially designed designators or tags for calling.

4.6.2 Fault-Isolation Software

The software presenting the interactive fault-isolation procedure can conceptually be one of three kinds:

a. Presentation of Automated Fault Trees. This approach corresponds to an interactive version of conventional fault-isolation diagrams or logic trees. The logic is all precompiled and the data are stored as a series of test-result-driven conditional branch instructions which lead to the next test to be performed, and ultimately to the fault-isolation result.

b. Deterministic Dynamic Procedures. This software approach will involve automated computation and presentation to the technician of the optimal troubleshooting path through a signal-flow logic tree, with display of test procedures and opportunity for the technician to input test results (which cause the delivery device to choose and present the next test proposed in the procedure). A straight logic-tree procedure should be modified (by the author) to adjust the test sequence in view of known test-times and component MTBFs, even though tests selected may be somewhat less sufficient in a purely "logical" sense, when such a departure can save the technician a significant amount of time.

c. Heuristic Approach. Using Artificial Intelligence (AI) techniques, a heuristic software approach would permit modification, either automatically or by work-center personnel, of the optimal test sequence only, as experience provides new information (test times, MTBFs

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based on experience, greater efficiency in grouping certain tests, etc.) which may be incorporated into the troubleshooting procedure to provide greater troubleshooting efficiency.

Initially, the Services will almost certainly choose one of the deterministic [(1) and (2)] approaches until tests and prototype experience can show the value, effectiveness, and reliability of the heuristic or Artificial Intelligence approach.

4.6.3 Special Software Capabilities

4.6.3.1 How-to-Use-This-System Information
The work-center delivery device will include in permanent disc memory a complete summary on how to use this Technical-Manual delivery system. This information should cover all aspects of all versions of the delivery device needed by the using technician to display Technical Information, and should explain how best to exploit the interactivity and special capabilities of the delivery devices. It should cover inter-relationships of the work-center device with other local logistic-support information systems, explain the use of the associated laser printer, and describe how to download information to the portable delivery device.

4.6.3.2 Built-In System-Test Software
The work-center delivery device should contain a software component which, on command, cycles through the major delivery-device functions to indicate the status of TM/delivery device availability. This software should test exhaustively the capability of the device to provide a technician with the

frames he needs for specific problems; and assure that (1) all calling sequences established by the author are valid and operable; (2) calling sequences implied by special-function keys are fully operable; (3) user-established calling sequences perform as indicated; and (4) there are no "lost" (unreachable) frames in the entire body of TI.

4.7 DISPLAY SUBSYSTEM CONSIDERATIONS

4.7.1 Advantages and Disadvantages of Screen Presentation

The use of a computer-governed luminous screen to display Technical Information to a using technician offers powerful advantages, which operational tests have shown conclusively to be highly attractive to Fleet technicians. The existing and emerging technology permits capabilities, mostly of an interactive nature, which are completely new to an area hitherto dominated by passive presentation of text and graphics on sheets of paper. At the same time, screen presentation has certain disadvantages (a major one is limited size). Furthermore, the optimum methods for presenting Technical Information via a screen, with or without many of the innovative capabilities, are not well understood.

Table 1 summarizes some of the functions that can be made available in an electronic-delivery system; however, it is by no means clear that many of these would in fact be beneficial.

4.7.2 Screen Characteristics

Screen design will require careful definition of a number of physical and performance parameters, a partial list of which is given on page 58, following Table 1.

TABLE 1.

A summary of some of the capabilities available
in Electronic Display Systems (EDS).
A comparison to paper capabilities is provided.

A.   PROGRAMMABLE CAPABILITIES

FUNCTION	COMPARED TO PAPER (+ Better than paper; = Equal; - Worse)	COMMENTS
1. Colors	+	Color is readily available when CRT-type displays are used.
2. Brightness, shading	=	Up to 16 levels of intensity; operator uses about 8 levels; codes best with 2-3 levels.
3. Black/white, white/black	=	For symbol coding, reverse video option available with CRTs. Light-controlled display can also do this.
4. Sizes	-	Range of size levels restricted on EDS by resolution and size of frame;
5. Positions	-	Positioning in regions of frame, or top-bottom, left-right order; fewer options with limited resolution.
6. Patterns	-	Texture, cross-hatching, codes more limited in EDSs due to resolution.
7. Linear codes	-	Include: underlining, boxing, connecting lines, arrows, in hardcopy. All linear codes more effective with paper.
8. Symbolic Codes	=	Include: letters, numbers, symbols. Equally effective for symbols.
9. Motion	+	Motion displayed on EDS, 5 to 60 frames/sec.
10. Flashing	+	Flashing at 3 Hz most effective.

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TABLE 1., continued

B. GRAPHICS

FUNCTION	COMPARED TO PAPER	COMMENTS
1. Perspective	+	Apparent depth can be shown with shaded-graphics techniques.
2. Motion/ Animation	+	Animation helps performance of actions, operator-equipment relation. TV-type motion illustrates action sequences.
3. Zoom	+	Allows operator to zoom in on image, and make it smaller or larger.
4. Windowing	+	Allows selection of part of larger image for display in CRT frame. Multiple windows on same source possible.
5. Overlay	+	Can be graphics or hardware overlay of graphs or images; possible to superimpose line art or symbols on video images.

C. SYSTEM

FUNCTION	COMPARED TO PAPER	COMMENTS
1. Page/frame handling	+	Rapid, accurate data processing to aid: storage, accessing, selection, and sequencing.
2. Complex logic algorithms	+	Algorithms implemented in computer software to aid rapid, accurate sequencing and aid in decision-making.
3. List searching	+	Replaces operator searching of lists or tables.
4. Interactivity	+	Operator may select procedure, request less or more information to fit skill level, modify pace for skill level, repeat information; learning, attention, motivation aided.

A PARTIAL LIST OF SCREEN DESIGN PARAMETERS

a. Screen type (CRT, plasma, electroluminescent, backlit LCD)

b. Screen size

c. Resolution

d. Color characteristics

e. Luminescence

f. Contrast ratio

g. Maximum viewing distance

h. Maximum off-center viewing angle

i. Refresh rate

j. Color vs Monochromatic

k. Distortion limitations

l. Animation or Motion

m. Highlighting

Tentative choices for these variables, based on tests and on analyses to date, are given in Appendix A. However, the mix is highly dependent on available technology which could change significantly in the next few years.

Certain design considerations for the display subsystem which strongly affect the user friendliness and suitability of electronic-delivery approach have been established:

a. There must be no observable flicker.

b. There must be no discernible stairstepping in either curves or diagonal lines.

c. <u>All</u> symbols displayed must be legible at the maximum distance specified. (This requirement involves also the TM design: frames may not be too busy; symbols must be large enough to see.)

d. All functions (e.g., Zoom, Windowing) must perform reliably as designed.

A touch-screen capability, or other screen position-indicating function, for use by the technician to select displayed choices, to position windows, to order parts from an exploded diagram, etc., will certainly be required.

4.8 COMMUNICATION SUBSYSTEM CONSIDERATIONS

As noted, the work-center electronic delivery device is intended to function as a node in a shipboard or shorebased communication system; i.e., a Local Area Network (LAN) with nodes linked by high-band-width data busses; with, for example, ethernet capabilities. The work-center TI delivery device must accordingly function as a two-way communications center. Some of the intended functions are as follows:

a. Into the Work Center

(1) Technical Information from a centralized library or other storage external to the work center, when the work center does not have the required Manual in its own storage.

(2) Requests for maintenance support from other areas, logistic-support information, response to questions, acknowledgement of reports submitted (e.g., maintenance action reports), requests for status reports.

(3) Rapid-action-change (RAC) data requiring immediate modification to specific Maintenance procedures. These changes are usually received through Naval Message traffic in a central location, and will be used to override an existing TM pending the arrival of a formal TM change.

b. <u>Out</u> <u>of</u> <u>the</u> <u>Work</u> <u>Center</u>

   (1) Requests for spare parts, materials, tools, test
       equipment for the work center from central storage
       facilities on the ship or base.

   (2) Maintenance-action reports, in accordance with
       standard Navy reporting formats (i.e., using 2-Kilo
       or VIDS/MAF forms generated largely by the work-
       center delivery device itself).

   (3) Reports of errors or deficiencies observed in the
       Technical Manuals employed by the work center, on
       forms (e.g., on the NAVSEA Technical Manual
       Deficiency/Evaluation [TMDER] form) completed
       through use of the work-center delivery device.

c. <u>Within</u> <u>the</u> <u>Work</u> <u>Center</u>
       It is intended that the work-center delivery device
   be capable of supporting the maintenance management
   function of the work center; i.e., that it be capable of:

   (1) Displaying assignments to each work-center
       technician, established by the work-center chief.

   (2) Displaying status reports to the work-center chief
       by each enlisted technician at the end of a watch
       or maintenance action.

   (3) Maintaining a record of maintenance status and
       history of all equipment under the cognizance of
       the work center.

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(4) Keeping track of and displaying planned-maintenance schedules (as well as displaying the required Technical Information) for all equipment under the cognizance of the work center.

The work-center device must also permit a technician to identify the Technical Information increment which will be needed for a specific maintenance action at a site remote from the work center, and must download this information to a portable delivery device so that the appropriate TI can be carried to the area involved.

5.0 USER INTERFACES

5.1 BENEFITS OF ELECTRONIC DELIVERY OF TECHNICAL INFORMATION TO FLEET TECHNICIANS

For the first time, Fleet technicians can be supplied with Technical Information for system logistic support which is innately suited to the effective performance of the technician's assigned task. Properly designed and presented, TI of this type can relieve the technician from the burden of carrying out tedious peripheral tasks (e.g., continued insertion of change pages as TMs are updated) and can provide him with information he can access quickly without the frustrations of searching through many Manuals and the continued necessity to refer to numerous sources cited by the information he finally finds.

Specifically, electronically delivered TMs will embody user-interface advantages such as the following:

a. Simplified, quick, multi-path access to information required for specific tasks;

b. Total elimination of referencing to other sources which must be physically acquired;

c. Major assistance (and prompting) in "filling out" forms which must accompany any maintenance action;

d. Automated computer-controlled update and correction of Manuals (a process which should be essentially transparent to the using technician);

e. Simplification of work-center maintenance-management procedures and equipment-status record keeping;

f. Intrinsically better (simpler, better organized and sequenced) presentation of Technical Information, leading to greater comprehensibility.

5.2 INTERACTIVITY

The single most significant characteristic of the computer-controlled luminous-screen delivery of digitized Technical Information is the capability of the technician to quickly select the information he wants, and the sequence in which he wants it displayed. In other words, the technician can direct the delivery-device function in a way that is unattainable with paper Manuals. At the same time, the delivery device (on the basis of preprogrammed algorithms) can propose choices and alternative information sequences which may be selected by the user; that is, the delivery device can prompt the technician's choices. Thus, there is a capability for man-machine interaction which, if properly designed, can greatly improve the efficiency of maintenance actions and can have a powerful effect on increasing system organizational availability.

Both the high potential and the need for careful design apply particularly in the presentation of troubleshooting information.

5.2.1 Interactive Troubleshooting

All three forms of the delivery devices (work-center, portable, embedded) will be required to present fault-isolation procedures interactively to permit a maintenance technician to locate one or more faulty components. In general, the procedure (which is built into the relevant TM) will lead the technician from a generalized report of equipment malfunction

to one or more specific trouble symptoms (a process called Fault Verification). When the existence of a fault has been Verified, and the appropriate trouble symptom entered, the delivery device provides the technician with an optimized test sequence which will permit him to identify the faulty components.

Using the keyboard, the technician must sequentially call (1) the troubleshooting portion of the TM, (2) the part of the troubleshooting information relating to the Subsystem for which a malfunction has been reported, and (3) the procedure contained in that part which deals with the type of malfunction reported (i.e., the troubleshooting procedure which will be presented to the technician when he has entered a trouble symptom).

Malfunction types will be cited in standard terms related to the weapon system; the delivery device will present a series of malfunction choices, one or more of which may be selected by touch-screen (e.g., "Power-Supply Malfunction", "Signal-Flow Problem", "Calibration Problem", "Display Problem"). For Fault Verification, the delivery system, when provided with the proper input information, will lead the technician through a logical sequence to one or more trouble symptoms (e.g., antenna fai.. to acquire target), couched in technical System-related terms, which then permit him to enter the detailed Fault-Isolation portion of the program.

The delivery device interprets a trouble symptom input by the technician in terms of the weapon-system signal-flow logic (which has been provided by the TM author) and identifies for the technician the most efficient first test of a sequence of tests which will ultimately lead him to identification of the faulty component. The system signal-dependency or logic-tree

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information which has been incorporated into the troubleshooting TM by the TM author, is "transparent" to the user.

The interactive sequence of information exchange between technician and delivery device during the Fault-Isolation procedure will then be as follows:

a. Identify the most efficient next test. Present setup and detailed test procedures (delivery device).

b. Carry out test (technician).

c. Present a statement of the Indication (test result) which constitutes a satisfactory equipment performance as a result of the test (delivery device).

d. Input a report that the test provided a satisfactory or unsatisfactory result (technician).

e. Identify most efficient next test (delivery device).

(Steps a. through e. are repeated until the first faulty component is identified.)

f. Identify the component first determined to be faulty (technician).

g. If the nature of the trouble system indicates that more than one component could be faulty, present the next most efficient test for further Fault Isolation (delivery device).

h. In any case, when a faulty component is identified, call the appropriate corrective-maintenance procedures (delivery device).

5.2.2 Interactivity by Special Functions

Table 1 presented a number of technologically feasible capabilities of the display subsystem (e.g., Scroll, Zoom, Windowing) which could greatly enhance the value of an electronic delivery system in presenting Technical Information to a maintenance technician or system operator.

In addition a number of interactive special functions can be designed into the presentation software (operable by the technician through use of a keyboard) to make the TI even more user-friendly and comprehensible. A partial list of such functions is shown in Appendix B.

5.2.3 Potential for Expansion of Interface between User and Delivery System

It is beyond question that the dialogue between the using technician and the computer-controlled delivery system can be improved greatly to facilitate the required information access and to improve TI comprehensibility and operational effectiveness. Much work remains to be done in the area of interactive electronic delivery of information, which is clearly an important information-system technology of the future, and has far broader implications than those limited to logistic-support Technical Information.

There has also been much speculation that TM automation opens the way for the Fleet technician to have on-line access, through his delivery device, to a broader data base, possibly

the design/manufacturing/test data base that the hardware contractor maintains in support of his own production process. Such a broadened access does not, however, appear warranted at this time. With the present Fleet-maintenance philosophy, all required Technical Information for weapon-system support should be carefully assembled and organized to provide even a marginally trained technician with what he needs to accomplish his task, but no more than that.

Nevertheless, as information-handling technology continues to improve, and with the advent of new weapon-system technologies, more sophisticated procedures involving the man/machine interface in weapon-system support may well prove to be effective. Numerous advanced concepts could be proposed (e.g., on-line participation in shipboard maintenance functions by skilled shore-based contractor representatives). Before implementation is attempted for such approaches, however, maintenance-system concepts and support infrastructure (as discussed in Sections 1.7 and 2.3) must be modified to accommodate them, and they must pass the tests of cost effectiveness and operational suitability, based on operational-environment testing.

5.3 THE AIR FORCE INTEGRATED MAINTENANCE INFORMATION SYSTEM (IMIS) CONCEPT

The IMIS concept, developed by the Air Force Human Resources Laboratory (AFHRL), exemplifies such proposed expansions of the total amount of Technical Information which could be made available to a system maintenance technician.

As the USAF IMIS RFP states[14], "The objective of the IMIS concept is to give technicians a rugged, portable computer to interface with other systems to provide an integrated source of information for all needed maintenance. IMIS will access various information sources, integrate information for presentation, and tailor information to fit the needs of the technician. It will effectively support technicians of various skill levels in hostile environments.

"As a technician's primary information source, IMIS will display graphic technical instructions, provide intelligent diagnostic advice, provide aircraft battle damage assessment and repair aids, analyze in-flight recorded parameters and failure data, analyze aircraft historical data, upload and download aircraft software, initiate, and interpret on-board tests. IMIS will validate faulty components prior to beginning off-equipment repair and support maintenance during off-equipment maintenance. IMIS will also provide easy, efficient ways to receive work orders, report maintenance actions, order parts from supply, and complete computer-aided training. IMIS enables optimum use of available manpower, enhances technical performance, improves training, and reduces support equipment and paper documentation needed for deployment.

"The IMIS concept includes four major subsystems: (1) the technician's portable computer; (2) a maintenance workstation connected to ground-based systems; (3) a maintenance interface panel connected to on-board computers; and (4) software for information access, integration, and presentation. The system also requires information authoring and updating capabilities

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14 USAF AFHRL ltr CC of 29 Apr 1988, Integrated Maintenance Information System (IMIS) RFP, F33615-87-R-0008, Statement of Work, Sections 1.3.2-1.3.4.

supported by efficient software maintenance and modification procedures."

To establish the feasibility, operational utility, and cost effectiveness of such concepts will require an extensive RDT&E effort, primarily in the areas of analysis and operational testing of concepts, and prototype testing. This approach represents a far more completely integrated information-system approach than is currently planned by the Navy. It will be extremely profitable to participate jointly with the Air Force in this effort to the extent that applicability of IMIS concepts to Navy system-support needs can be analyzed and tested.

6.0 TECHNOLOGICAL ISSUES AND PROBLEMS

6.1 REMAINING TECHNOLOGY GAPS

Although a number of prototype "delivery devices" have been developed by Industry, some of which have been field-tested (largely to establish the validity of the TM electronic-delivery concept), no existing militarized package has been shown to meet both the functional and the environmental requirements. It is expected that all Services will in fact procure and perform prototype tests on such devices in the next few years. Even though the three major hardware components of such a system (microcomputer, memory, and display) are state-of-the-art (at least for the work-center device), much work remains to be done in:

    a. packaging the delivery function into a reliable, low-maintenance device; and

    b. incorporation of reliable software to assure accurate rapid display of the Technical Information.

6.1.1 Portable Delivery Device

For the portable device, a cathode-ray-tube display will probably not be suitable (from the standpoint of both weight and power-requirement). However, a number of technical problems remain to be worked out for existing flat-panel displays, to assure good visibility (adequate resolution and contrast), reliable operation, low power drain, and moderate cost and ease of maintenance.

6.1.2 Oversized Graphics

For any electronic-delivery device, the problem of viewing an over-sized drawing or schematic in its entirety has not been solved. Such drawings are usually handled (unsatisfactorily)

as foldouts in paper Manuals. Although the provision of scrolling, augmentation of the delivery device by a laser printer (up to about 11" x 17"), and breaking large drawings down into logical sub-units will partially solve this problem, additional work needs to be done.

6.1.3 Compatibility of Software in Authoring System and Delivery Device

A significant technological problem remaining is the design of compatible software so that a TM author, working with a sophisticated automated work station, can establish information-access paths in digital Technical Manuals in such a way that the user can navigate by these paths solely through use of the delivery-device controls available to him. Much experience remains to be achieved with prototype devices before this particular problem can be considered solved on a Service-wide basis.

6.1.4 Need for Prototype Testing

Extensive prototype experience will also be required to establish the smooth flow of TM from the authoring contractor, through the Navy's acceptance-test procedures, distribution to the using activity in suitable combination with other TMs, and, finally, interactive display to the user in support of maintenance or system-operation tasks.

6.2 NEED FOR A REDESIGNED TM-SUPPORT INFRASTRUCTURE

The Navy Technical Manual support infrastructure consists of those organizational activities, facilities, support systems, and processes that are utilized to perform the functions of acquisition, storage, control, replication, and distribution of the Navy's Technical Manuals. Its importance as part of the overall system approach needed to support

automated Technical Manuals was pointed out in Section 2.0. However, this infrastructure is currently designed to support paper TMs. To perform these functions for automated TI intended for electronic delivery to Fleet technicians, it must be significantly modified.

When re-designed, this infrastructure will continue to perform existing functions, but with computer-controlled equipment and with automated techniques. It will also have two new functions: (1) mastering of optical-disc media to be utilized in replication, and (2) organization of Technical Manuals into bundles sized to the capacity of the optical-disc media and the requirements of the individual using activities.

The initial goal of the Navy's effort to update this infrastructure should be to achieve a capability which can support all technological improvements implemented in the near future by the SYSCOMS, as described in Section 7.2. The final goal will be an integrated Navy-wide system for the complete support of a fully automated TM system.

6.3 NEED FOR IMPROVED INFORMATION DISPLAY TECHNOLOGY

The way to achieve optimal formatting for the interactive display of Technical Information is not well understood. Much work still needs to be done in this area, which will require careful attention to human-factors considerations. Maximum effectiveness of the delivery systems from the point of view of the user requires careful design of the screen itself (see Section 4.7.2) and of the keyboard and position-indication system (e.g., touch-screen, mouse, or other form of cursor control). The keyboard must be designed not only so that it is convenient to operate, but also so that key-originated special functions are comprehensible and reliable. Access-

times for a called frame must be so short (one second or less)
that the user does not feel the delay. Equipment must be
reliable, with long MTBFs. Maintainability of the delivery
device (e.g., physical accessibility to significant subsystems)
must be carefully designed-in.

6.4 POTENTIAL INTERACTION WITH ATE AND BITE

A number of complex systems, particularly those with
digitized operating systems, have Built In Test Equipment
(BITE) which performs routine tests on the system to establish
its operational conditions. Sophisticated fault-isolation
routines can be built into equipment of this type (e.g., in the
avionics suite of an aircraft). The possibility that such BITE
could be designed to communicate directly to an electronic
delivery system and thus eliminate or shorten an extensive man-
conducted fault-isolation procedure, has been considered. The
Navy has, however, not as yet expressed a requirement for this
function, because of the potential complexity, cost, and
uncertain reliability of such equipment. Experience of the Air
Force, with the PCMAS (Portable Computer-based Maintenance Aid
System) which contains this requirement, will be monitored
carefully.

7.0 CURRENT AND PLANNED NAVY EFFORTS IN
TECHNICAL MANUAL AUTOMATION

In support of the strategic goal for Navy TM automation cited in Section 1.7, a number of individual projects have recently been completed, are in process, or have been proposed, to achieve Technical Manual automation throughout the Navy. Efforts that are directly or indirectly relevant to acquisition of electronic-delivery functions for the digitized Technical Manuals of the future are described in this Section.

7.1 THE "PAPERLESS-SHIP" ATM INITIATIVE

With support from the SPAWAR Technical Data Center, the Navy is currently planning a shipboard evaluation of a number of Technical Manual automation methods. The proposed test will take place on selected operating ships, and will involve converting page-oriented Technical Manuals for screen display and local print-on-demand. The objectives of this program are to:

a. Assess the value of replacing shipboard paper TMs with an optical disc file, with onboard printing of needed pages or TMs.

b. Assess value of TM electronic display in work centers.

c. Assess maintenance-performance improvement through use of electronic display and printing of pages needed.

d. Evaluate Fleet acceptance and human factors involved.

There is currently an unfunded proposed effort for the SNAP Office of SPAWAR and the NTIPS Office to work together to install onboard ship a demonstration work-center ATM system, supported by necessary shorebased support systems. The shipboard system would include six portable delivery devices, with a high-speed data-downloading capability. The shorebased

support station would include a high-speed data transfer system, and would be supplemented with two portable delivery devices.

7.2 CURRENT NAVAL SYSTEMS COMMANDS INITIATIVES

Fleet and shorebased efforts are currently being carried out by the Naval Sea Systems Command, the Space and Naval Warfare Command, the Naval Air Systems Command, and the Naval Publications and Printing Service to evaluate:

a. Conversion of existing paper TMs to digitized form with raster-scan or Optical Character Recognition (OCR), and use of advanced storage media, to produce greater efficiency in transferring TMs direct to the user and in providing both centralized and local Print-On-Demand capability;

b. Initial automation and maintenance of Technical Information libraries at user activities and aboard ship;

c. Improvements in indexing and information-retrieval features of existing TMs, through digitization and incorporation of standardized automated location procedures for specific items of information;

d. Requirements for and approaches to improvements in the Navy's TM-support infrastructure, leading to a capability to acquire, control, and distribute digital TMs.

7.3 NAVY PARTICIPATION IN CALS STANDARDIZATION ACTIVITIES

The Navy will participate in CALS Standardization programs, particularly those relating to any aspect of the system required to produce a smoothly operating sequence from Automated Technical Manual authoring through the delivery phase, to assure that Navy requirements are taken into account, and that the Navy can implement resulting DOD directives and standards.

7.4 RDT&E PROGRAM

As the Navy's designated Lead Laboratory for Automated Technical Manual RDT&E, The David Taylor Research Center will continue to support the Navy's program to acquire and use digitized Technical Manuals. Efforts will be primarily in the following areas:

a. Analysis of specific requirements for, and RDT&E support of, design and acquisition of the proposed Navy-wide TM-automation system, including the capability for interactive display.

b. Operational tests of automation concepts and methods to assess their suitability and effectiveness in the Fleet, for both air and surface applications.

c. Monitoring and analysis of technical progress of Industry, and evaluation of newly developed devices and approaches to TI automation, particularly in the electronic-delivery area, using the Automated Technology Laboratory established by DTRC for that purpose. (See Section 3.6.)

d. Preparation and coordination of specifications and standards for automated (digitized) Technical Information, the form in which the digital data stream is to be delivered, and the detailed nature of the electronic delivery devices to be acquired for Fleet use.

e. Participation in the essential standardization efforts among the Services, the Department of Defense, and Industry to eliminate a potential proliferation of technical approaches (including hardware, software, and Technical Manual form) to TM automation.

f. Conducting or participating in prototype tests of procedures or equipment in the Navy leading to the implementation of NTIPS concepts and other ATM initiatives.

g. Conduct of joint RDT&E efforts with other Services to assure inter-Service transmission of technological information, avoid duplication of effort, and achieve DOD-wide standardization in the entire CALS area to the maximum possible extent.

7.5 INTER-SERVICE RDT&E COORDINATION

The Navy will carefully monitor and coordinate its RDT&E efforts (to be carried out by DTRC) with the Air Force, the Army, and the DOD. Through inter-Service cooperation, Navy requirements will be incorporated into the other Service developments wherever possible, thus assuring a maximum degree of standardization.

Joint Service development and prototype evaluation of advanced automation-system improvements will be of great benefit to all Services in making most effective use of resources, and in maximizing Service commonality of TM hardware and software, TM specifications, and TM-control procedures. A common Service approach to TM automation will also reduce the number of technological alternatives which must be provided by Industry, an action resulting in less expensive, more effective, and more timely ATMs in support of weapon systems.

Specifically, the Navy will carefully monitor and coordinate its RDT&E efforts with the Air Force Integrated Maintenance Information System (IMIS) program, an RDT&E program which has been established to develop, demonstrate, and install a prototype automated TM system for field evaluation (see Section 5.3); and with the Air Force Technical Order Management System (AFTOMS), which will provide an infrastructure for the acceptance, management, and use of electronic Technical Orders. The Air Force IMIS effort will lead to a comprehensive, automated TM demonstration system, consistent to a large extent with principles developed under the Navy's NTIPS program.

The U.S. Army has recently initiated its four-phase ACALS (Army CALS) program[15] the purpose of which is to "establish the baseline for the evolutionary modernization of the process for the capture, storage, and processing of logistic technical information required to acquire and support weapon systems". The Navy will carefully monitor the progress of this effort, as well as the Army's ongoing development of its MEIDS (Militarized Electronic Information Delivery System) portable electronic TI delivery device.

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[15] U.S. Army Information Systems Selection and Acquisition Activity, RFP DAHC94-88-R-0008, 29 July 1988, Army Computer-aided Acquisition and Logistic Support.

7.6 PILOT WEAPON-SYSTEM IMPLEMENTATIONS OF ATM TECHNOLOGY

During the next several years, the Navy will equip selected aircraft, ship, and weapons systems, which will be in the design phase in the near-term and mid-term time frames, with fully automated Technical Manual systems as TM automation pilot platforms. These efforts, which will involve a full range of electronically displayed logistic-support Technical Information for logistic support for the systems chosen, will:

a. provide valuable initial (prototype) experience for TM automation for entire systems;

b. apply the benefits of TM automation to new weapon platforms and weapons systems of the Navy, in accordance with the directions of the Deputy Secretary of Defense[3];

c. through subsequent integration into a longer-term, more widely integrated TM automation system, form a technological, organizational, and procedural bridge which will serve as the foundational effort for the longer-term effort.

7.6.1 TM Automation Demonstration under the A-12 Program

A four-year Automated-TM demonstration program has been planned in conjunction with the A-12 aircraft development and acquisition program. The first-year contract task and program initiation are expected in the second quarter of FY 89. The goal of this demonstration is to gain enough experience with real data in an operational maintenance environment so that the A-12 Program Manager can make informed decisions in acquiring production Technical Manuals in electronic (Type C) form rather

than in traditional paper format. The demonstration will also serve as a model for other Navy frame-based electronic-TM system experiments and pilot operations, and will also permit generation of detailed specifications for such a capability in a form that could be used by other DOD program managers.

This prototype effort will comprise the following tasks:

a. A TM Utilization Analysis. This effort will determine optimum organization and content of the Technical Information required at each level of A-12 maintenance and will provide the optimal mix of media for most effective use of the TI. It will also establish requirements for conversion of existing data to fully interactive TI in terms of both technology and organization.

b. Development of Specifications. Specifications will be developed for a prototype Type C electronic display system and for the Technical Information to be displayed by it; i.e., for an Interactive Electronic Technical Manual (IETM) System. These specifications will be based on the recent draft Navy Specifications cited in Section 3.5, and on other available draft specifications such as those planned for delivery by the DOD-chartered Aerospace Industries Association (AIA) Paperless Technical Manual Study Group working with representatives from each of the Services as part of the CALS Program. The final set of specifications compiled and developed under the A-12 task will be sufficiently detailed to provide the basis for design and acquisition of a prototype operational system.

Specifications to be completed will include:

(1) IETM User System Definition, Hardware/Software Functions, Output Requirements, and System Interface Requirements

(2) IETM Presentation Formats

(3) IETM Data Content and Data Stream

(4) IETM Technical Content

(5) IETM Quality Assurance Program Requirements

c. **Design, Construction, and Demonstration of a Prototype System**. The demonstration will include both Technical Information and the associated Display System. Commercially available hardware (including portable delivery devices) will be used to the extent possible, and already prepared TI will be converted to an interactive, electronically displayed form.

d. **Assessment of Prototype TM Automation System**. This effort will evaluate the applicability of the prototype interactive TMs and the TM-display system for supporting the operational A-12 aircraft, and prepare applicable acquisition specifications required to implement the automated system.

e. **Incorporation of an Intelligent Diagnostics Capability**. The demonstration will include incorporation of an intelligent troubleshooting subsystem which will allow a maintenance technician to isolate a fault, using

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interactive procedures built into the portable interactive maintenance device. This portion of the overall effort will be started in FY 90 and will be designed to advance the state-of-the-art of automated diagnostic aids.

Information developed under this A-12 pilot program will be made available on a continuing basis to the IMIS and CALS programs and to other on-going TM automation efforts of the Services.

APPENDIX A

Listing of NTIPS Design Characteristics for

Electronic Delivery Systems

LISTING OF NTIPS DESIGN CHARACTERISTICS
FOR ELECTRONIC DELIVERY SYSTEMS

Design Characteristic	NTIPS

A. CONDITIONS OF USE

1. Environmental

Work-center device, several of which may be net worked together in a large ship or shore station, suitable for use in work-centers aboard ship, or on any Naval Base where Organizational, Intermediate, or Depot Maintenance is carried out.

Work-center devices are supplemented by a larger number of portable devices for remote-site operations/use.

These portable devices must be small enough to be hand held and ruggedized so as to be reliable in a ship-board or flight deck operational environment.

Device must be useful for all weapon-system training functions.

---

2. Personnel

a. Skill/knowledge level

User-tailored and skill-sensitive TI presentation.

Inteded primarily for Technicians with training in specific system maintenance (e.g., C-school) and higher. Use of system will require prior training (but not computer training).

Multi-track TI not required. Single track presentation oriented to fully trained user with optional additional data for inexperienced user and skipping provisions for experienced user. Some flexibility; e.g., creation of personal checklists will be permitted (automatically) for designated, experienced users.

Help and "How-to-Use" information built-in.

A. CONDITIONS OF USE (Continued)

    2. Personnel (Continued)

b. Task-management requirements	Sign-on procedures established for each technician in each work-center. Work Center Chief uses device for making assignments (maintenance mgt.); user uses device for maintenance status reporting.

c. Job Requirements	1. System operation.
	2. Planned Maintenance.
	3. Corrective Maintenance.
	   a. Organizational
	   b. Intermediate
	   c. Depot
	   (Including troubleshooting/diagnostics)
	4. Other Logistic Support Functions.

d. Record of User Actions	Will provide report of user actions (primarily for maintenance management, maintenance action reporting, automatic preparation of other logistic-support documentation), limited to record of tasks accomplished and required logistic support reporting.

    3. Operational

a. Number of device units per work-center	The TI delivery system shall consist of as many work-center data-base nodes as there are work-centers. Each work-center may have up to 6 work-center devices and up to 10 portable devices. Requirements would be based on specific work-center functions.
b. Number of different systems supported	TI available at each work-center device will be that required for all systems on the ship or station (e.g., any work-center device would be able to access all data available on ship).
c. Number of simultaneous users of the device	Each device is a single user device.
d. Portability	Portable device must be capable of being easily hand-held and used at any site on ship or station where TI is performed. (Portable device shall weigh 10 lb or

A. CONDITIONS OF USE (Continued)

    3. Operational (Continued)   less). Work-center device remains on
                                          bench in work-center.

---

        e. How to use instructions   Help and how-to-use Instructions must be
                                            included with the device. Prior instruc-
                                          tion in device use must be provided.

---

        f. Organization of devices   Work-center devices can be entirely
           within the system   autonomous. Portable devices must be
loaded from a work-center device every
time a maintenance action is performed.
However, devices can be net-worked to-
gether for communications between work-
centers for logistic support functions
and file sharing through data-base net-
work (LAN).

---

        g. Interfaces with   At this time, there is no requirement
           operational system   that the terminal have a buss to connect
to test equipment (BITE, BIT, or ATE) so
that delivery system can directly
measure or monitor for signals from
the equipment under test.

The data transmission interface among
work-centers and with the stations
central ADP capability shall be by
a general purpose interface buss
as yet unspecified.

---

        h. Modes of operation   Work-center device shall be capable of
operating when connected to a data-base
node or as a stand-alone unit. Most of
the TI will be recorded on a non-volatile
memory (e.g., optical disc) available to
a Work-Center Device.

Portable delivery devices can be
"loaded" (draw their TI) by
down-loading directly from a work
center device (with up to several
hundred frames of TI) and carried
to remote work sites for specific
tasks.

The Device shall have six modes of
operations:
            1. Display TI to Technician
               (Display TI to support
               preventive and corrective
               maintenance and system

A. CONDITIONS OF USE (Continued)

   3. Operational (Continued)   operation). (Primary mode of
       h. Modes of operation (Con'd)   use.)

   2. Generate TIDER (Technical
       Information Deficiency Evaluation
       Report) (After being called up,
       this program prompts user for
       information needed to generate
       the deficiency and evaluation
       reports; generation of most
       of the report is automatic;
       if operating stand alone,
       report is stored in terminal
       unit until a dump to data
       base node is possible).

   3. Request for parts from local
       on-board or on-station supplies,
       via central ADP Supply System.

   4. Provide to central collecting
       facility required maintenance
       action forms (3M, or Maintenance
       and Material Management actions)
       in accordance with automated
       audit trail and input from user.

   5. Train. (With training applica-
       tion software, device shall
       operate in an interactive,
       training mode.)

   6. Permit Work-Center Chief to
       exercise functions of Main-
       tenance Management (specific
       work assignments, maintain
       status of work-center mainten-
       ance load).

B. HARDWARE

   1. Device

      a. Dimensions   Work-center devices: small enough to
                           pass through normal ship ingress.
                           Height: no greater than 30 inches.
                           Width: no greater than 18 inches.
                           Portable device: not to exceed
                           12"x12"x4" (12"x9"x2" preferred) .

B. HARDWARE (Continued)

   1. Device (Continued)

      b. Weight

           The work-center device shall weigh no more than 35 pounds including memory device.

           The portable device shall weigh no more than 10 lb. (Separate Battery pack may weigh 5 lb   extra).

----

   2. Memory

      a. Type
         i. Primary

           Read-only very-high-density non-volatile media (e.g., laser-optical based).

----

         ii. Secondary

           Read/Write high density magnetic (e.g., hard-disk).

----

         iii. Working Memory

           Internal RAM possibly augmented by very low access time hard disk.

----

      b. Functions
         i. Primary Data
           Base

           Data may be a mixture of bit mapped pages, vector uncoded graphics, and ASCII-encoded text and tables. Several hundred thousand page-equivalents must be available, not necessarily on-line at one time.

----

         ii. Secondary Data
           Base

           On-line random access magnetic storage holding "up date" information to read only data base. Less than 5% of primary data base. On-line to net-worked work-station device. Will also contain data and programs needed to operate the device and perform its collateral data collection (i.e., TIDER and logistic support data) and reporting.

----

         iii. Working Storage

           High speed on-line memory capable of holding sufficient electronic TI to perform a specific task (up to 500 page-equivalents of data). The function and size will be the same on both the portable and the work-station device; however, the media may differ.

----

      c. Capacity
         i. Primary Data

           Exact Capacity will depend on coding structure not yet specified. On the order of tens of gigabytes. (500,000 page-equivalents).

B. HARDWARE (Continued)

    c. Capacity (Continued)

        ii.   Secondary Data
              Base   A minimum of 100 megabytes.

----

        iii.   Working Storage   A minimum of 10 megabytes. Subject to
                                    revision when exact coding structure is
                                    specified (500 page-equivalents).

----

    d. Expandability

        i.   Primary   Unlimited, storable as off-line media.

----

        ii.   Secondary   Expandable to 500 megabytes.

----

        iii.   Working Storage   TBD - Larger capacity desirable but may
                                      be limited by available technology and
                                    cost on portable device.

----

3. Power

    a. External   Work-Center and portable devices capable
                               of operating from external power sources
                               (115V, 60 Hz, AC) by means of an external
                               cable.

                               Portable device must be equipped with an
                               optional separate battery pack to provide
                               4 hours of continuous operation. Battery
                               pack must be separately portable and
                               attached as required.

----

    b. Internal   Because of weight requirements battery
                               is to be external.

----

    c. Fail-safe provisions   The work-center and portable devices
                               shall have a fail-safe provision such
                               that loss of external power will not
                               cause loss of on-line (auxiliary) memory
                               (TI is on non-volatile memory).
                               Internal batteries to preserve volatile
                               memory when external battery drops below
                               level to operate device.

                               The power supply shall protect the system
                               from overvoltages or other transients.

----

    d. Power management   The battery pack for the portable device
                               will be rechargeable and will be equipped
                               with a charge-condition indicator.

B. HARDWARE (Continued)

    4. Durability/Environment   The work-center devise and portable
                                    device will be designed to operate
        a. Life   for 10 years based on a preventive
                                    maintenance program.

---

        b. Resistance to: Devices shall with-stand Procedure I
          i.   Shock   shock as specified by Method 516.2,
                                    MIL-STD-810.

                                    Design shall be such as to prevent shock
                                    sensitivity, instead of reliance on
                                    shock-mounting.

---

          ii.   Vibration   Shall withstand standard vibration tests
                                    of MIL-E-16400G.

---

          iii.   Temperature   Operating: 10 to 50 degrees C.
                                    Non-operating: -18 to +66 degrees C.

---

          iv   Moisture   Shall withstand non-condensing humidity
                                    as follows:
                                        Operating   5 to 95%
                                        Non-operating 0 to 100%

---

          v.   Atmospheric Operating   0 to 10,000 ft;
                pressure   Non-operating 0 to 40,000 ft;

---

          vi.   Oil/chemical/dirt Must operate with full TI visibility in
                                    extremes of environment when Navy main-
                                    tenance is performed (flightlines to
                                    shipboard).

                                    Must be resistant to fluid spills; and
                                    capable of immediate cleaning (by wiping)
                                    if contaminated with oil, grease,
                                    chemicals, etc.

---

          vii. Salt   Must withstand Standard Salt Spray List
                                      of MIL-E-16400G

---

          viii. Fungus   Shall withstand fungus growth typical of
                                      tropics, as specified by MIL-E-16400G.

---

          ix.   Resistance to   Must not respond to microwave
                Electromagnetics radiations; must withstand EMP effects;
                                    must pass TEMPEST requirements. An
                                    additional-non TEMPEST model to comple-
                                    ment TEMPEST model if economics dictate.

B. HARDWARE (Continued)

    4. Durability (Continued)

        b. Resistance to: (Continued)

vii.	Salt	Must withstand Standard Salt Spray List
x.	Thermal shock	Must withstand the rate of 16 degrees/second.
xi.	Inclination	Must operate at an inclination of +/- 15 degrees at a rate of up to 0.12 Hz; inclination of 90% while energized but not operating shall not adversely affect subsequent operation.
xii.	Airborne acoustic noise	
xiii.	Dust	Device shall be adequately sealed to prevent ingress of dust or other contaminates, with specific attention given to disc-inserting provisions.
xv.	Ambient light level	Display shall be visible in total darkness (i.e., must be self lighted); display shall be visible in direct sunshine.

    5. Reliability and maintainability

a.	Availability	The device shall be available >97.5% of the time when operating at 100% of benchmark capacity. The equipment shall withstand non-operating periods of 6 months.
b.	MTBF	>2,000 hours.
c.	Mean time to repair	45 minutes using system diagnostics.
d.	Mean time to replace	15 minutes for component module.
e.	Prevention maintenance requirements	Shall be conducted at the organizational and intermediate levels by Navy technicians. A test procedure shall be provided for fault identification as a preventive maintenance measure by work-

Design Characteristic   NTIPS

B. HARDWARE (Continued)

    5. Reliability and maintain-
        ability (Continued)
        e. Prevention maintenance   center technicians. The procedure shall
            requirements   require no disassembly of any part of the
            (Continued)   system. (System corrective maintenance
                                      TI shall be provided as part of the
                                      total ship or station TI).
                                      ----
        f. Parts interchangeability Like parts or components shall be inter-
                                      changeable as specified in MIL-E-5400.
                                      ----
        g. Fault isolation   Built-in self-test to replaceable com-
                                      ponent level in power up.
                                      ----
            i. Special tools/test   No special tools or test equipment
                equipment   needed.
                                      ----
    6. Storage   Storable without external packaging.

        a. Orientation   Capable of storage in any orientation.
                                      ----
    7. Installation   No special installation required (All
                                      units simply require plug-ins to iden-
                                      tified power or data-buss receptacles.
                                      ----
    8. Health and safety   MIL-STD-454, Requirement No. 1 should
                                      apply.

                                      Materials must not create noxious fumes
                                      under combustible conditions.
                                      ----
    9. Packaging   There must be no special packaging
                                      requirements. Portable device will be
                                      incorporated in permanent carrying case,
                                      completely self-contained including
                                      extendable power cable. Battery pack
                                      will be separately packaged.
                                      ----
    10. Transportability   Transportable by air, surface, ocean
                                      carriers.
                                      ----
    11. Display

        a. Display type   Work-center Display - Analog RGB CRT.

                                      Portable Display will be flat and
                                      monochromatic.

                                      Displays shall have 1/2"-resolution
                                      touch screen overlays.

Design Characteristic	NTIPS

B. HARDWARE (Continued)

b. Display size — Active display area of at least 6.4 inches by 9.6 inches. The viewing orientation may be either portrait (vertical) or landscape.

   i. Text — NTIPS TI will in general consist of text/graphic modules.

----

   ii. Graphics — See statement under Text.

----

c. Resolution — The minimum average pixel density shall be 100 pixels per inch vertically and horizontally. 640 x 960 pixels on entire display.

----

d. Luminance (Brightness)

----

e. Contrast Ratio — Contrast ratio shall be a minimum of 5:1, in operational conditions of near darkness to bright sunlight.

----

f. Viewing distance and angle — The display shall be clearly legible at any distance up to 1 meter. Design viewing angle is 90 degrees; the display must be legible within +/- 30 degrees from this value (i.e., +/- 30 degrees from the normal to the display.

----

g. Refresh rate — No display flicker shall be allowed.

----

h. Color — Display shall be Monochromatic on the portable device and full-spectrum color for the work-center device.

----

i. Distortion — The combined optical, mechanical, magnetic, and electronic distortion shall not be greater than 1% of the active display area.

----

j. Animation/motion — The Mass storage unit shall be capable of supporting still or animated illustrations.

A software provision shall be made to display contiguous pages of data at a minimum of 10 complete pages per second to accommodate animation sequences, if needed.

B. HARDWARE (Continued)

    11. Display (Continued)

        k. Highlighting   Highlighting shall be used to emphasize key information. Highlighting techniques (electronic) include flashing.

---

        l. Windowing   A capability of up to three widows shall be provided. There shall be no limitations as to what TI may be retained in a window.

---

        m. Obstruction   View of the screen shall be unimpeded within +/- 30 degrees from the normal to the center of the screen.

---

        n. Expandability   Work-center device optional display size of approx. 13" x 10" (1280 x 960 pixels.)

---

    12. Keyboard

        a. Type   On Work-center device - full alphanumeric keyboard plus numeric and special keypad plus 10 function keys.

                                   On Portable Device - Numeric and special function keypad plus 10 function keys, Provision (i.e., Jack) for full alphanumeric keyboard.

                                   Special functions to be Next, Back, Help, Exit, and Enter.

---

        b. Number of keys   Standard keyboard; 18 keypad plus 10 function keys on portable. The work-center keyboard must permit entry of all ASCII characters.

---

        c. Key dimensions   Standard Typewritten size. Option for one-inch spacing on portable.

---

        d. Key layout   Standard keyboards with special function keys added. Exact layout TBD.

---

        e. Type of keys   Keys shall provide tactile feedback.

---

        f. Special function keys   Only Next, Back, Help, Exit and Enter to be fixed.

                                     Use of function keys dependent on delivery software. May vary with TI.

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B. HARDWARE (CONTINUED)

    12. Keyboard (Continued)

        g. Programmable keys   No user programmable function keys.

----

    13. Audio Input/Output   The NTIPS work-center and portable
                                      devices have no requirements for voice
        a. Speaker   input or output. The device shall
                                        have an audible "beeper" which can be
                                      sounded under program control.

            i. Location   --

            ii. Frequency response   Approximately 1000Hz narrow band.

----

            iii. Audible range   Two Meters.

----

        b. Microphone
            i. Integral

----

            ii. Hand-held

----

            iii. Head-mounted

----

            iv. Directionality

----

            v. Frequency response

----

            vi. Noise suppression

----

            vii. Effective range

----

        c. Earphone
            i. Type

----

            ii. Frequency response

----

        d. Voice recognition
            i. Enrollment

----

            ii. Reaction time

----

            iii. Vocabulary size

----

            iv. Suppression

----

        e. Voice synthesis
            i. Vocabulary size

----

            ii. Expandability

Design Characteristic	NTIPS

B. HARDWARE (Continued)

14. Printer

The work-center delivery device shall be supplemented with a graphics page printer to produce hard copy TI.

Provisions shall be made for the coupling of the screen printer to the work-center device.

----

15. Communication Links

   a. Modem

Modem linkages will not be used.

----

   b. Networking

The interconnection of the work-center device and communication nodes may be by direct cable, fiberoptics with permanent plug-in, or jacks.

The interconnections among data base nodes may be achieved by standard data busses. (Not yet specified.)

Work-center interfaces consist of all communication between the data base nodes and direct connections to portable or bench units connected to it.

C. SOFTWARE
1. Information Content

   a. Procedural

TI in the NTIPS data base is primarily procedural, or as the NTIPS style specification calls it, text/graphics modules.

----

   b. Diagnostic

NTIPS requires a special system for computer guided troubleshooting. This system prompts the user to follow the most efficient logic tree.

This system will be usable on both the work-center device and the portable device (in the latter case when the suitable TI has been down-loaded). It involves performance of tests by the technician and insertion of results to the device, which will then display the optimal selection of the next step. It will also display step-by-step instructions on how to perform the test.

C. SOFTWARE (Continued)

    1. Information Content (Continued)

c.	Prompting	Prompts are used in support of menu access, troubleshooting, and form completion; e.g., TI Deficiency Reporting (TIDER).
d.	Graphics	Work-center and portable devices must both be capable of scroll and zoom for best possible view of graphics. Portable device use may be accompanied by paper copy of a graphic obtained from screen printer in work-center.
e.	Segments and symbols	

    2. Commands

a.	Recall	Capability to store and recall up to three windows or displays. The display of stored information shall be in its original form.
b.	Next/Back	Back and Exit selections must be available at all times. Where sequence is unbranched, next selection must be available at all times.
c.	Scroll	Whenever a graphic or text/graphic module of size greater than 6.4"x9.6" is displayed, horizontal and vertical scroll capabilities must be provided to the full extent of the graphic.
d.	Enlarge/Reduce	Zoom capability from 1/4x to 4x enlargement must be provided.
e.	Offset	User may offset the center of his viewing window to any point on the display area. Scale will not change unless user initiates a separate scaling command.
f.	Pan	Specifically use of one or more windows shall not hinder the scroll capability. User shall be able to pan windows within a display.

C. SOFTWARE (Continued)

      g. Item designation

i.	Cursor including home position	Keyboard or touchscreen cursor control to allow line item selection.
ii.	Touch	(See item i above.)

      h. Data entry   A card entry is under consideration for the work-center device.

The TI provided to the technician cannot be changed by the technician. The only data-entry process involves responding to prompted requests for specific test results in the fault-isolation process, and information required to complete certain forms/reports.

The data-entry devices for the work-center and portable-delivery units shall be: keyboard and touchscreen.

3. Characters

a.	Size	Variable. Resolution of system must permit legible presentation of 10-point alphanumerics.
b.	Case	Upper and lower.
c.	Characters per line	Minimum of 80.
d.	Number of lines per frame.	Minimum of 25 in landscape mode and 50 in portrait mode.

4. Organization

5. Authoring   As virtually all Navy Presentation TI is purchased from Industry, NTIPS does not require any particular authoring process. Specifications used to procure TI for electronic delivery will govern:
        1. Presentation method (format, style, organization for text-graphics modules)
        2. Structure and digitization of the data stream itself.

C. SOFTWARE (Continued)

5. Authoring (Continued)	In-house tests will assure that the delivered TI is in accordance with specs and compatible with delivery device.
6. Update/revision	Each delivery device shall be equipped so that the technician can center data relative to 3M, TI update, and spares requests. However, the technician can not alter the TI itself.

Work-center devices will accept limited on-line electronic transfer of TIupdated material through Navy's Rapid Action Change (RAC) program. This material will be designed to over-ride specific portions of TI where urgent corrections are required, and will apply until TI is revised, through TI update which will be accomplished through physical delivery of non-volatile transportable memory devices (e.g., optical disc) using U.S. Mail, parcel post, messenger, etc.

----

7. User alerts   TI will contain usual Technical Manual cautions, warnings, and notes. No special user alerts for work-center system. A user alert will warn when battery pack for portable device is runing out of charge.

----

8. Logic

    a. Fixed Sequence   Next or Back command available at all times in unbranched procedures (e.g., in corrective-maintenance sequence).

----

    b. Branching   Since possibility of alternative choices is a primary advantage of electronic display, certain branches will be always available (help, exit) and maximum use will be made of branching where logically possible (e.g., selection of TI; fault-isolation process).

----

9. User ccess   Primary type of TI:
                        1. Preventive maintenance TI
    a. Types of TI   2. Fault Isolation TI
                        3. Corrective Maintenance TI
                        4. Logistic-Support TI (e.g., IPB)
                        5. Training TI

C. SOFTWARE (Continued)

    9. User access (Continued)

a. Types of TI (Continued)	All content, format, style, arrangement, data-stream structure, requirements for these types governed by NTIPS specs.
	The TI from any data base node (sets of work-center devices) can be accessed by (the devices in) any other data base node in the system by working through the network and work-center interfaces. This is a back-up measure.
b. Means of access	
i. Menu	Menus will always be available, but procedures will be provided for direct access to required specific TI without sequential use of menus.
ii. Direct	After entry (possibly by card) routine on the work-center device, user may call up desired data by TM number, subsystem number, part number, prearranged call, trouble symptom, and other methods. Direct access will be emphasized and permitted in as many ways as possible.
iii. Search	Associative pointer indices and key word retrieval. Prompting techniques for rapid convergence on desired information.
iv. Query language	Query language not specified. NTIPS specs will define functional requirements for system hardware and software simultaneously; query architecture will thus be part of overall hardware/software package for work-center.
10. Display response time	Worst case access time shall be less than 5 seconds for display of an entire frame, average access time to next frame shall be less than one second.

APPENDIX B

Special Functions for Improving Interactivity

Between a User Technician and the Electronic Delivery Device

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APPENDIX B

This appendix summarizes possible special functions which could improve the interactivity between a user technician and the electronic delivery device. A fuller discussion is given in the proposed specification MIL-M-TIEDS[8]. The names assigned to such special functions (if field tests show their operational value) must, of course, be standardized; names are assigned in this Appendix only to illustrate the nature of the capabilities involved.

Exercise of special functions could be through incorporation of a special function key into the delivery device keyboard or by use of an assigned alphanumeric character or sequence.

a. **NEXT**

Calls the next frame in numerical sequence (next higher number) for display. Generally for use in unbranched sequences.

b. **BACK**

Calls back for display the frame which was viewed immediately before the present frame.

c. **HELP**

Permits the technician to call to the screen special descriptive information which has been inserted into the TM by the author. Such information is intended to explain some technical point which the author expects will be unusually difficult for the technician, to define a specific term, or to provide a fuller explanation of some process covered very briefly by the TM.

d. COMMENT

Calls for display a specially designed item of information, called a Comment, inserted into the TI at a specific point to inform the user as to some special condition, warn against some possible error, emphasize the importance of a specific instruction, and the like; but which the author does not consider of sufficient general applicability to insert into the primary procedural statement at the risk of impeding its continuity or reducing its comprehensibility.

e. RELOCATE (offset)

Using the touch-screen or other position-indicating capability, the user may offset the frame center to any position on the viewing screen by means of the RELOCATE special function key.

f. FORM

The FORM special function, followed by a brief alphanumeric sequence, can be used to call one of the types of electronic "blank forms" which the technician must "fill out" as required to complete his maintenance Task. These are:

(1) Maintenance Action Reporting form;

(2) Technical Manual Deficiency Reporting (TMDER) form (a form used to report both errors and areas of incomprehensibility in the TM);

(3) Part Ordering form.

Once the form is displayed, those blanks which the system has not already filled out automatically can be completed by insertion of required alphanumeric symbols with the alphanumeric keyboard. (Not used on the portable delivery device.)

g. HOLD

Exercise of the HOLD function, followed by a brief alphanumeric sequence, establishes a call point so that a technician can more easily return to his place in a given TM sequence (via a Call) if it is necessary to interrupt the maintenance procedure for an indefinite time. The HOLD function may be used to establish any number of such specific calling points at which the technician finds it personally convenient to enter the TM frame sequence. They will remain in effect until eliminated (by replacing existing HOLDs with defaults).

h. CALL

Exercise of the CALL special function, followed by an alphanumeric sequence, retrieves from memory and displays on the screen the desired frame of Technical Information. A Call may be based on:

(1) Frame number;

(2) A calling sequence established by the TM author, based on subsystem component, part, or other equipment-oriented address with regard to which a technician may need information;

(3) Alphanumerically inserted function or class of Technical Information; e.g., troubleshooting, for a system, subsystem, or component; or

(4) A location previously established by a technician using the HOLD function.

Establishment of alternate, easy-to-use, direct calling sequences to enable the technician to reach the information he needs in a minimum of time, and in general the user-friendliness of this CALL function, represent primary considerations in the operational suitability of the delivery-system design.

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i. RECORD (notepad)

A function which transfers to a personalized record (notepad) material compiled by the technician and maintained by the delivery device, in addition to the TM material, consisting of either of the following:

(1) Alphanumeric information keystroked into the system following exercise of the RECORD function;

(2) Material from any of the frames of the TM selected by the SELECT special function.

j. RETURN

The RETURN function returns the screen display from the frame currently displayed in the sequence to the frame representing the closest previous node in the TM sequence established by the TM author; e.g., exercise of the RETURN function upon completion of a Subtask, will display the first frame of that Subtask; a second exercise of RETURN at that point will return the display to the initial frame of the Task. In troubleshooting TI, RETURN will re-display the frame at the beginning of the present branch.

k. SELECT

Designates material displayed at that time for inclusion in a personalized record via the RECORD function. SELECT also designates material (e.g., a specific frame sequence) which will be down-loaded onto a magnetic disc or other designated medium by the WRITE function; for example, downloading from a work-center delivery device to a portable delivery device.

l. WRITE

Used only in the work-center device to download selected Technical Information into a portable delivery device. Exercise of the WRITE function will record, on portable-

delivery-device memory, material which has been designated by the SELECT function.

APPENDIX C

LIST OF ACRONYMS

LIST OF ACRONYMS

A-12   An Aircraft development program of the U.S. Navy

AC   Alternating Current

ACALS   Army-CALS (program)

ADP   Automatic Data Processing

AE   Aviation Electrician's Mate (U.S. Navy enlisted rating)

AFHRL   Air Force Human Resources Laboratory

AFTOMS Air Force Technical Order Management System

AI   Artificial Intelligence

AIA   Aerospace Industries Association

AIMD   Air Intermediate Maintenance Division

AIR   (Naval) Air Systems Command   (See NAVAIR)

ASCII   American Standard Code for Information Interchange

ATE   Automated Test Equipment

ATI   Automated Technical Information

ATM   Automated Technical Manual

BIT   Built-In Test

BITE   Built-In Test Equipment

CAD   Computer-Aided Design

CAE   Computer-Aided Engineering

CALS   Computer-aided Acquisition and Logistic Support

CD/ROM Compact Disc/Read-Only Memory

CNO   Chief of Naval Operations

COMNAVSURFLANT   Commander, Naval Surface Forces, U.S. Atlantic Fleet

CRT   Cathode-Ray Tube

DBMS   Data Base Management System

3-D   Three-Dimensional

DEPSECDEF   Deputy Secretary of Defense

DOD   Department of Defense

DTRC   David Taylor Research Center

EDS   Electronic Display System

ET   Electronic Technician (U.S. Navy enlisted rating)

HM&E   Hull, Mechanical, and Electrical (shipboard equipment)

IETM   Interactive Electronic Technical Manual

ILS   Integrated Logistics Support

IMIS   (U.S. Air Force) Integrated Maintenance Information System

IPB   Illustrated Parts Breakdown

LAN   Local Area Network; cf. WAN

LCD   Liquid Crystal Display

3M   Maintenance and Material Management

MEIDS   Militarized Electronic Information Delivery System (program of the U.S. Army)

NALCOMIS   Naval Air Logistics Command Management Information System

NAMTRADET   Naval Air Maintenance Training Detachment

NAVAIR   Naval Air Systems Command

NAVAVNDEPOT Naval Aviation Depot (formerly called NARF, Naval Air Rework Facility)

NAVINSGEN   Naval Inspector General

NAVSEA   Naval Sea Systems Command

NSY   Naval Shipyard

NTIPS   Navy Technical Information Presentation System

NTP   Navy Training Plan

OCR   Optical Character Recognition

OMN   Operations and Maintenance, Navy (funding category)

PCMAS   Portable Computer-based Maintenance-Aid System

QA   Quality Assurance

RAC   Rapid Action Change

RDT&E   Research, Development, Test, and Evaluation

RFP   Request For Proposals

RGB   Red, Green, Blue (color-capable Cathode-Ray Tube)

SECNAV   Secretary of the Navy

SIMA   Shore Intermediate Maintenance Activity

SNAP   Shipboard Non-tactical ADP Program

SPAWAR   Space and Naval Warfare Systems Command

SYSCOM   (U.S. Navy) Systems Command

TI   Technical Information

TIDER   Technical Information Deficiency/Evaluation Report

TIQAPP   Technical Information Quality Assurance Program Plan

TM   Technical Manual

TMDER   Technical Manual Deficiency /Evaluation Report

USAF   United States Air Force

VF   U.S. Navy Designation for a Fighter (Aircraft)
          Squadron

VIDS/MAF   Visual Information Display System/Maintenance
               Action Form

WAN   Wide Area Network; cf. LAN

WORM   Write-Once, Read Many (times); a form of disc storage

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